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ABSTRACT

A computer model for providing information to assist space administrators at the University of Toronto in planning classroom requirements is presented in this thesis. The requirements generated are compared against available rooms and measures of utilization computed. The model reacts to changes in parameters describing the system which allows the resource implications of alternative space planning decisions to be considered. (Author)

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A COMPUTER SIMULATION MODEL FOR
PLANNING INSTRUCTIONAL FACILITIES AT
THE UNIVERSITY OF TORONTO

by

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This thesis is submitted in partial
fulfillment of the requirements
for the degree of
MASTER OF APPLIED SCIENCE

Department of Industrial Engineering
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W. F. Sceviour

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A computer model for providing information to assist space administrators at the University of Toronto in planning classroom requirements, is presented in this thesis. The requirements generated are compared against available rooms and measures of utilization computed. The model reacts to changes in parameters describing the system which allows the resource implications of alternative space planning decisions to be considered.

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I INTRODUCTION

I.1 University Space Planning - The Problem

The University of Toronto, with an enrollment of 27,000 (including part-time students), is the largest University in Canada, and is situated on a very expensive 160 acre plot of land in downtown Toronto. Increasing enrollment, increasing demand for educational services, expanding research activity, and the ever-changing curricula are stressing the University's physical facilities. This heavy demand for space emphasizes the need for efficient management and utilization of existing space and more systematic and careful planning of new facilities. Capital appropriations for physical facilities must be properly controlled and planned; otherwise excessive sums of money may be allocated for incorrect and inadequate facilities. The complexities of this urban institution, rapidly changing educational goals, rising construction and land costs, lack of information, and many other problems burden University space planners. There are, however, three conventional solutions to solve the space problem.

First, restrict the size of the student body to fit available space. This method, although feasible, is incompatible with the University's goal to provide for all qualified students the opportunity to receive a formal education beyond high school.

Second, increase the physical facilities to accommodate the proliferating student body. This approach is concordant with institutional aims but not entirely practicable because of scarce University resources and a heavy demand on public funds by the various Ontario Universities.

Third, create a higher utilization of existing space to accommodate more students along with a well planned building program for inadequate facilities. This approach is the desirable one, but the most difficult to fulfill. It involves several important planning steps. A detailed plant study must be made and/or updated to indicate available space and equipment, present utilization, and adequacy for present University enrollment. Since most major University expenses such as administration and plant operation, teaching staff, maintenance, building construction, and teaching equipment relate to the function of instruction, the instructional programs should be evaluated to determine optimum class sizes, faculty teaching load, unit expenditures for instruction, suitability of physical facilities for programs, and so on. The characteristics of the students including geographical origin, professional and vocational goals, their passing, failing, transfer, and dropout rates must be studied and combined with forecasting formulas to prognosticate enrollment at the University and the breakdown of this enrollment into the many academic departments. The University's fiscal policies and financial structure requires careful analysis to reveal trends in the University's primary sources of funds, and the present and expected expenditure of these funds for the institution's various programs (the latter known as 'Program Budgeting'). The final planning step is integrating the results from each of the studies to determine the extent of instructional plant necessary. Then, appropriate faculty and administrative committees in conjunction with a competent architect can determine the size, location, design and timetable of new construction or renovation.

At a large University like Toronto, the space planning studies outlined seem a formidable undertaking when considering the time, manpower, and money involved. Fortunately, the University of Toronto possesses one of the largest and most sophisticated computer systems in Canada. The use of the computer's high speed for information processing, and University analysis and planning, was investigated in early 1965 with the development of a systems simulation model for the Faculty of Arts and Science, bearing the acronym CAMPUS (Comprehensive Analytical Method for Planning in the University Sphere). This model contains a space requirements section which forecasts space for professorial offices, lecture rooms, laboratories, administrative offices, etc. The pilot study indicated many advantages of a computer simulation model for University space planners and decision makers. Space planning studies can be undertaken and large volumes of data rapidly analyzed to enable planners to renovate or build for changes in educational objectives and methods, and increasing enrollment.

I.2 Institutional Research and Simulation

To investigate and solve the problems of higher education and to carry on institutional self-studies, many universities and colleges now employ an analytical group under a director of institutional research. According to Henry S. Dyer (7) institutional research is centered around two points of view. The first approach is theoretically orientated, long term studies of the inner workings and science of educational institutions. The institutional research group should devote itself solely to research and be relatively free from solving current operational problems. The second view is that institutional research should be assigned the responsibility for studies necessary for the making of important decisions about policy and procedure. The analytical effort should emphasize the means of using limited resources to better advantage.

The University of Toronto and most other universities with institutional research bureaus are endeavouring to integrate both of these approaches. Operational research, uninformed by theory is less effective. New theorems and techniques must be developed or adapted from the literature and applied to provide better solutions for institutional problems. An institution must have well organized information and data systems in order to measure the resource implications of its policies and goals.

One of the newer techniques employed by institutional researchers is experimentation with university simulation models. Observation, familiarization, and discussion of the university system leads to the formulation of hypotheses explaining the system's operations and behaviour. These hypotheses are translated into a set of mathematical equations (a model) which describes the system and can be used to predict changes in the state of the system. Usually the mathematical model is written according to a particular set of rules so that the model can be processed by a computer rather than solved analytically. The model must be tested and validated to determine whether the desired correspondence between it and the real system has been attained. Simulation is the process of conducting and analyzing experiments on the model instead of attempting the experiments with the real system. Experiments are carried out by varying the model's decision parameters and the numerical values assigned to the model's independent variables.

The construction of a simulation model for planning lecture room facilities at the University of Toronto is explained in this report. In addition, the process of investigating the implications of changes in the university's system by experimentation on the simulation model is illustrated.

I.3 The CAMPUS Model

The CAMPUS model is a systems simulation computer model developed to provide information which will assist University of Toronto administrators. The model is a series of routines to analyze input data on University activities, compute the resulting resource requirements over a specified time period, and display the information on computer-prepared reports and graphs. The CAMPUS model consists of the following four main sections:

1. Enrollment Formulation
2. Resource Loading
3. Space Requirements
4. Budgetary Calculations

Based on forecasted entering enrollment, and passing, failing, transfer, and dropout rates, the Enrollment Formulation section computes for each department the number of subject-students (lecture and laboratory) expected in each academic year for each session simulated. The computations of the Enrollment Formulation section are transferred to the Resource Loading section which calculates and reports the staff requirements and teaching workload of all academic departments. Certain parameters set by department decision makers, such as teaching hours per week per staff member, desired class sizes, number of hours per week in each lecture and laboratory subject taught, and so on, must be supplied. Next, the Space Requirements section of CAMPUS computes requirements for lecture rooms, laboratories, professorial offices, libraries, and other types of space, and compares the requirements against present and projected facilities. Space deficiencies and space utilizations are reported, and the costs of constructing new facilities to cover shortages are estimated. The final section determines the departmental and faculty budgets for the various types of academic staff, non-academic salaries, research funds, and so on. The time series of the most important annual expenditures are drawn by the CalComp Plotter.

The CAMPUS model was developed originally to assess the feasibility of the systems simulation approach to university problems. It was limited to undergraduate instructional activities within the Faculty of Arts and Science of the University of Toronto. There was considerable interest in the pilot project, and the experience gained from CAMPUS indicated the construction of a systems simulation model for the University of Toronto was feasible. Consequently, the Office of Institutional Research undertook the implementation of the pilot model and the expansion and development of CAMPUS as a systems simulation model for the entire University, including both undergraduate and graduate instruction.

Further, more detailed information on the CAMPUS model may be obtained from the publication A New Tool for Educational Administrators.(10)

I.4 Project Objectives and Organization of this Thesis

The primary objective of the research work of this thesis was the development and improvement of the elementary space planning methodology of the Space Requirements Section of CAMPUS. The research work was to include the insertion of real rather than hypothetical data into the model. Initially two approaches to the problem were conceived, namely:

(i) Development of a system simulation model for determining the physical facilities requirements (including lecture rooms, laboratories, offices, libraries, and other areas) for a small group of departments such as those that form the Faculty of Applied Science and Engineering or the Faculty of Arts and Science.

(ii) Development of a university wide planning model for selected types of space.

Approach (i) would involve the study of problems associated with forecasting requirements for many types of space. However, such a study, even for a small faculty, would require a lengthy literature search, collection of copious amounts of data, and perhaps considerable modification when extending the model to include other faculties at the University of Toronto. Important inter-relationships among faculties such as the cross-appointing of professors, the flow of students from one faculty to another for lectures, and the allocation of space in a building occupied by two faculties, can only be examined in a larger university-wide model. Clearly, the development of a university space planning module within the framework of the CAMPUS model was the wisest and most practical goal. Since data were available from the Department of Statistics and Records describing the University's lecture room facilities, and because of the author's undergraduate experience and interest in the problems of low seat and room utilizations, approach (ii) was initiated for tutorial, seminar, and lecture rooms.

The goal of the thesis project was to develop, implement, and test:

- a system for integrating the CAMPUS model input enrollment data and projecting future lecture room requirements.
- a routine to provide statistics on available lecture rooms.
- a matching procedure for comparing lecture room requirements against available space, calculating utilization of space, and defining space deficiencies.

This report is presented in two major divisions - the body and the appendix. The body of the thesis describes what the computer program does, and the appendix answers how the program does this. The body contains a description of each aspect of the methodology, and the many considerations essential to the development of a space management and planning program. Section VI of the body is rather unique in that it can be examined separately by educational planners and space researchers of other institutions to enable them to gain an appreciation of the model. Institutions contemplating the use of the computer in a formal space planning program could then obtain further detail from the remainder of the body of the thesis and the appendix. The reader of the complete report will benefit by now reading Section VI then returning to body Sections II through V. The computer produced reports from the program subroutines were reduced and placed together in Section VI rather than being interspersed in the commentary of the other Sections of the body.

The appendix contains the supporting information for an in-depth examination of the model mechanics. Detailed flowcharts, program subroutine listings, and the glossary of variable names will be of assistance in understanding the operation of the program, and in tailoring it to another institution.

II THE MAIN PROGRAM

The computer simulation model developed is a series of approximately 1000 FORTRAN IV instructions broken into six sections as shown in the 'Overall Program Structure' diagram of Appendix B. The group of statements which controls the calling of the various subroutines is referred to as the main program. A complete listing of the computer statements and flowcharts for the main program can be found in Appendix B. The main program contains the instructions necessary to read the data cards, control the calling of different subroutines over several simulation periods (depending on the input values of control parameters), and print several reports.

The accuracy of the information produced by the mathematical relationships of the model is dependent on the numerical values assigned to the independent variables of these relationships. The sources and meaning of the input data, problems associated with obtaining these data, and some assumptions are described below. The variables are listed in the sequence that data are read into the computer, and the actual numerical values for the variables are enumerated in Appendix C.

a) NDP, NFACUL, NDIST, NTOTAL, NPRIOR, IACA, NINTI, IBEGIN, IEND, UTEAWK, SUTAL, RUTIL, SSTOP, SKIP, SULOW, SULOWD, THIS, COSTIN - These are the system parameters. Their function is outlined in Section VI, Table I, and that section demonstrates the different information that may be produced by varying the values of these system parameters.

b) BLDG, NBLDG, NROOM, SEATS, NODEPT, NUPDTE, NRES, SQFT, NCHECK, NFAC - These are the array names of the input information describing each seminar, lecture, and tutorial room available in the University of Toronto's physical plant. The meaning of the information is explained in Section IV of the thesis and will not be examined here.

c) ROLEES, STR, HL, ITEST - The data furnished by these arrays are extremely important for the calculation of classroom requirements as described in Section III.4. The arrays ROLEES, STR, and HL, contain the forecasts from the Enrollment Formulation module of CAMPUS of the number of enrollees, the average class size, and the average number of weekly hours per lecture subject, respectively, for each academic year of every department. An 'enrollee' is defined as a subject-student. For example, suppose that two hundred third year engineering students were taking a History course. The number of enrollees or subject-students is 1x200 or 200. Further, these two hundred enrollees would be added to the enrollee total for third year honours History since this department must provide the staff and space for instruction. The summation of the number of students expected in each of the subjects offered in a particular academic year equals the enrollee forecast. The average class size is simply the weighted average of the class sizes taught in all the subjects offered in a particular academic year. The average number of weekly hours per lecture subject is obtained by dividing the total number of lecture hours for all subjects by the total number of sections taught.

The Enrollment Formulation section of CAMPUS generates the departmental enrollee forecasts by breaking the entering or new enrollment into the many University departments, by applying failing, passing, and transfer rates to the previous year's enrollment, by multiplying the number of students enrolled times the number of departmental subjects offered to their own students, and where necessary, transferring enrollees among departments. The methodology is outlined in the Office of Institutional Research publication OIR-6. The research work for this thesis was carried on concurrently with the development of the Enrollment Formulation section and the insertion of real data into that section. However, the Office of Institutional Research was unable to provide the forecasts contained in ROLEES, STR, and HL in a machine processable form in time for testing of the thesis program. For this reason, enrollment data from the University of Toronto President's Report for the year ended June 1966 was analyzed by hand for each academic department. A sample analysis for the Botany department is shown in Figures II-1, 2, and 3. This analysis will clarify the meaning and calculation of the information contained in ROLEES, STR, and HL. The number of enrollees computed for the base period was increased by two percent each simulation period to provide an indication of the space requirements of each department over the next ten years.

Two methods for calculating classroom requirements are described in section III.4; one using the average class size as the size of room desired, and the other requiring a distribution dividing the enrollee forecast into various room

INSTRUCTION IN THE FACULTIES, SCHOOLS, AND INSTITUTES OF THE UNIVERSITY, 1965-1966

FACULTY OF ARTS AND SCIENCE

UNIVERSITY OF TORONTO

Botany

Name of Subject	No. of Subject	No. of Sections	Given to Students of the Faculty of	No. of Students Lect.	No. of Students Lab.	No. of Weekly Hours Lect.	No. of Weekly Hours Lab.
Biology	310	2	Arts & Science	191	191	1	6
Biology	490	1	Arts & Science	18	18	¾	3¼
Botany	100	1	Arts & Science	74	74	2	2
Botany	101	1	Arts & Science	35	35	1	3
Botany	110	4	Arts & Science	330	330	4	8
Botany	170	2	Arts & Science	158	158	2	4
Botany	200	1	Arts & Science	6	6	2	2
Botany	210 (With 110)	2	Arts & Science	77	77		
Botany	270	1	Arts & Science	10		3	
Botany	271	1	Arts & Science	41	41	2	3
Botany	272	2	Arts & Science	71	71	3	2
Botany	300	1	Arts & Science	6	6	2	2
Botany	310	1	Arts & Science	10	10	2	3
Botany	311	3	Arts & Science	70	70	2	9
Botany	320	1	Arts & Science	13		2	
Botany	370	1	Arts & Science	30	30	2	1½
Botany	371	2	Arts & Science	33	33	3	3
Botany	372	1	Arts & Science		6		1
Botany	373	1	Arts & Science	5	5	1	3
Botany	374	1	Arts & Science	3	3	1	3
Botany	470	1	Arts & Science	3	3	1	3
Botany	471	1	Arts & Science	8	8	1	3
Botany	472	1	Arts & Science	2	2	1	3
Botany	473/1003	1	Arts & Science	2	2	1	3
			Graduate Studies	4	4		
Botany	474/1024	1	Arts & Science	2	2	1	3
			Graduate Studies	2	2		
Botany	475/1021	1	Arts & Science	2	2	2	3
			Graduate Studies	8	8		
Botany	476	1	Arts & Science	10	10	1	3
Botany	477/1040	1	Arts & Science	6	6	1	3
			Graduate Studies	4	4		
Botany	1st Year	1	Food Sciences	28	28	1	3
	1st Year		Forestry	23	23		
Botany	3rd Year	1	Forestry	22	22	2	2
Botany	1001	1	Graduate Studies	3	3	1	3
Botany	1005	1	Graduate Studies		3		3
Botany	1007	1	Graduate Studies		2		3
Botany	1023	1	Graduate Studies	4		1	
Botany	1030	1	Graduate Studies	3	3	1	3
Botany	1031	1	Graduate Studies	2	2	1	3
Botany	1053	1	Graduate Studies	1		2	
Botany	1060	1	Graduate Studies	1	1	1	3
Botany	1061	1	Graduate Studies	2	2	1	3
Botany	1st Year	1	Pharmacy	135	135	2	3

SUMMARY DEPARTMENT OF BOTANY

	No. of Students Lect.	No. of Students Lab.	No. of Weekly Hours Lect.	No. of Weekly Hours Lab.
Arts & Science	1,216	1,199	44¾	82¾
Food Sciences	28	28	1	3
Forestry	45	45	2	2
Graduate Studies	34	34	8	21
Pharmacy	135	135	2	3
TOTAL	1,458	1,441	57¾	111¾

Figure II-1

FIGURE II-2

DEPARTMENT OF BOTANY
CALCULATION OF THE ARRAYS STR, HL, AND ROLLEES
DATA FROM FIGURE II-1

SUBJECT	NUMBER OF SECTIONS	NUMBER OF STUDENTS	HOURS PER WEEK	SECTION SIZE	ACADEMIC YEAR	CALCULATION
Botany 100	1	74	2	74	First Year General	STR = 439/6 = 73.2 HL = 7/6 = 1.17 ROLEES = 439.0
Botany 101	1	35	1	35		
Botany 110	4	330	4	82		
	6	439	7			
Botany 200	1	6	2	6	Second Year General	STR = 83/3 = 27.7 HL = 4/3 = 1.33 ROLEES = 83.0
Botany 210	2	77	2	38		
	3	83	4			
Botany 300	1	6	2	6	Third Year General	STR = 277/7 = 39.6 HL = 7/7 = 1.00 ROLEES = 277.0
Botany 310	1	10	2	10		
Botany 311	3	70	2	23		
Biology 310	2	191	1	95		
	7	277	7			
Botany 170	2	158	2	79	First Year Honour	STR = 344/4 = 86.0 HL = 5/4 = 1.25 ROLEES = 344.0
Botany - Food Sciences - Forestry	1	51	1	51		
Botany - Pharmacy	1	135	2	135		
	4	344	5			

Botany 270	1	10	3	10	Second	STR = 122/4 = 30.5
Botany 271	1	41	2	41	Year	HL = 8/4 = 2.00
Botany 272	2	71	3	35	Honour	ROLEES = 122.0
	4	122	8			
Botany 320	1	13	2	13	Third	STR = 106/7 = 15.1
Botany 370	1	30	2	30	Year	HL = 11/7 = 1.57
Botany 371	2	33	3	17	Honour	ROLEES = 106.0
Botany 373	1	5	1	5		
Botany 374	1	3	1	3		
Botany - Forestry	1	22	2	22		
	7	106	11			
Botany 470	1	3	1	3	Fourth	STR = 53/8 = 6.6
Botany 471	1	8	1	8	Year	HL = 9/8 = 1.12
Botany 472	1	2	1	2	Honour	ROLEES = 53
Botany 473	1	6	1	6		
Botany 474	1	4	1	4		
Botany 475	1	10	2	10		
Botany 476	1	10	1	10		
Botany 477	1	10	1	10		
	8	53	9			
Botany 1001	1	3	1	3	School of	STR = 16/7 = 2.3
Botany 1023	1	4	1	4	Graduate	HL = 8/7 = 1.14
Botany 1030	1	3	1	3	Studies	ROLEES = 16
Botany 1031	1	2	1	2		
Botany 1053	1	1	2	1		
Botany 1060	1	1	1	1		
Botany 1061	1	2	1	2		
	7	16	8			

FIGURE II-2 CONT'D

sizes. If the average class size is to be used in the calculations for a particular academic year the indicator ITEST = 0; otherwise ITEST = 1.

d) AMIDPT, BINT - Classroom requirements are calculated for rooms of several different sizes. A size breakdown was formulated based on the capacity of rooms constructed in the past at the University, and corresponding approximately to a division suggested by Central Room Allocation - Department of Statistics and Records. The following room size ranges (or intervals) were chosen for planning purposes:

Size (Students)	Interval Mid-point	Description
0-20	10	Small seminar or tutorial room
20-60	40	Large seminar room
60-100	80	Small lecture room
100-180	140	Large lecture room
180 up	250	Lecture theatre

The room size interval end points are contained in the array BINT and the mid-points in the array AMIDPT. Since a larger or smaller number of modular room sizes may be more appropriate for other institutions using this computer program, and to allow for experimentation at the University of Toronto, both arrays are dimensioned for up to seven room sizes.

e) DIST - Often many different class sizes are taught in the subjects offered by a department in a particular academic year. A certain percentage of the enrollees in that academic year may receive instruction in small seminar or tutorial rooms, while others are instructed in lecture theatres. In order to indicate which sizes of rooms are required by a department, a measure of the percentage of enrollees expected to be attending

Department of Botany

Example Calculation of a Percentage Distribution

Data from Figure II-2.

Procedure:

1. Sum the number of enrollees in each room size range by examining the section size.

2. Divide by the total number of enrollees and multiply by 100% to obtain the percentage of the enrollees in each size interval.

   Example: Third year General Botany - 277 enrollees.

Subject	Enrollees	Section Size	Room Size Range
Botany 300	6	6	0-20 students
Botany 310	10	10	0-20 "
Botany 311	70	23	20-60 "
Biology 310	191	95	60-100 "
Total	277		

Percentage Distribution

Room Size Range	Calculation	Percentage
0-20 students	$\frac{(6+10)}{277} \times 100$	5.7%
20-60 "	$\frac{70}{277} \times 100$	25.3%
60-100 "	$\frac{191}{277} \times 100$	69.0%
100-180 "		0.0%
180 and over		0.0%

Figure II-3.

classes in rooms of each size is needed. This percentage distribution is stored in the array DIST. The method of computing this distribution is illustrated in Figure II-3 for the Department of Botany, third year General.

The initial distributions were based on enrollment data by subject from the President's Report for the session 1965-66. The assumption is made that these departmental distributions remain the same for planning simulations run for several years into the future. This assumption is valid because of the difficulty in predicting a change in departmental teaching methods. In addition, the room size ranges selected are wide enough that a pedagogical decision to, say, double tutorial class sizes from seven to fourteen will not alter the percentage of enrollees requiring rooms of capacity 0-20. The departmental distributions will be adjusted annually by the Office of Institutional Research based on the enrollment data for the latest session.

f) DPNAME, DRUTIL, TEAWK, AMTOFF, ASSIGN - These arrays store departmental data. The names of the academic departments at the University are listed in Appendix A and are carried in the array DPNAME. The array DRUTIL contains the departmental room utilizations, i.e. the percentage of the time per week that available rooms are scheduled for lectures. Room scheduling at the University of Toronto is managed by Central Room Allocation and the room utilization for each department was set equal to the 60% value experienced by this central group. The ability to differentiate between the scheduling efficiency of one department and another may be helpful for other institutions with disaggregate room scheduling. The length of the teaching week for a particular department is supplied by the array TEAWK. Frequently classes of two or three people are instructed in a professor's office rather than a tutorial room. Accordingly, the departmental room requirements for tutorial rooms are reduced by a certain percentage, stored in AMTOFF, which reflects how often this occurs. The array ASSIGN indicates how many rooms of the smallest size range are required by a department for conferences and special presentations beyond normal instructional requirements.

g) BLDPRI - The main program next reads this array containing a list of buildings for each of the forty-seven academic departments (refer to data in Appendix C). The building numbers in the list correspond to those employed by the Physical Plant Department. When the computer searches for lecture rooms to satisfy a department's needs, the first building on the list is examined, then each succeeding building is searched based on rules and assumptions stated in Section V. In general the building of first priority (first on the list) is the department's home building, and the most neighbouring buildings are listed next. In this manner appropriate classrooms for scheduling a department's lectures will probably be located close to a department's academic offices.

h) AVGISS - The requirements for lecture rooms are forecasted for five different sizes of rooms. Since the size ranges are relatively wide, it would be advantageous to know whether a department required a room with a capacity closer to the upper or lower boundary of a size interval. For this reason the weighted average section size (AVGISS) for each interval was calculated from the enrollment data contained in the President's Report.(14) The expression used to calculate the average section size for a particular department and room size interval is:

$$\text{AVGISS} = \sum_i (\text{Hours/week})_i \times (\text{Section size})_i \Big/ \sum_i (\text{Hours/week})_i$$

for all i subjects having class sizes in that room size interval.

As an example, consider the data for the Department of Botany shown in Figure II-2, and choose the size interval of 60-100 students. The subjects with class sizes in this interval are Botany 100, Botany 110, Biology 310, and Botany 170. Therefore,
$\text{AVGISS} = ((2\text{x}74)+(4\text{x}82)+(1\text{x}95)+(2\text{x}79))/(2+4+1+2) = 729/9 = 81$
The program would search for lecture rooms in the interval 60-100, but would endeavour to find the room closest in capacity to 81 students.

i) FACNAM, NDPFAC - For the purpose of summarizing departmental information into faculty reports, the number of departments in each faculty (NDPFAC) and the names of these faculties (FACNAM) are read into the computer.

After reading numerical values for the variables described under (a) to (i), the main program calls subroutines FACIL, ORCAST, UWIDE, and MATCH for the specified number of simulation periods. Different options and reports are possible depending on the values of the control parameters. However, this discussion is left to Section VI. The main program also contains instructions which control the calling of subroutine MATCH for several values of the seat utilization parameter SUTAL in order to achieve the best matching of required and available space. This function of the main program is described in Section V.

The main program next instructs the computer to print several different reports from the information produced by the various program subroutines. The first series of reports outline the forecasted departmental lecture room requirements. A typical departmental report is shown in Figure 7 of Section VI of the thesis. This report indicates the forecasted number of lecture room-hours for each room size range, the corresponding number of rooms required, and the values of the parameters in the relationships which calculate the number of rooms. In addition, the lecture rooms are listed that were found during the matching process to satisfy a department's needs.

Reports of the forecasted space requirements for the faculties which contain more than one department are now printed. A sample report for the Faculty of Applied Science and Engineering is shown in Figure 9 of Section VI. The shortage or surplus of lecture rooms at the faculty level could be established by comparing room requirements to facilities available in the faculty's buildings.

This lecture room planning model accepts forecasts from the Enrollment Formulation Section of CAMPUS for up to ten simulation periods. In addition to the reports which appear for each session simulated, a time series of the total University of Toronto lecture room requirements over several years is printed on a report shown in Figure 4 of Section VI. This information is a summary of the yearly university-wide matching report described under Section V.1. The values shown for each size interval represent the actual number of rooms short or in excess of requirements after comparison with the available university facilities. The effects on future lecture room requirements of varying decision parameters such as the length of the university teaching week, lecture subject hours, and class sizes can be studied on this report.

Figure 4 includes an indication of the construction cost for rectifying a shortage of lecture rooms. Land acquisition costs are not included in the cost equation. The main program calculates construction costs using the following relationship:

Example: Construction cost of tutorial rooms (size interval number one)

CCOST(1) = COSTIN x ROMEAN(1) x AVGINT(1) x RMDIFF(1,1)

where CCOST(1) = The construction cost of rooms of the first size interval (dollars).

COSTIN = The construction cost index in dollars per square foot.

ROMEAN(1) = The average size of rooms built in the size interval 0-20 students.

AVGINT(1) = The average number of square feet per seat for tutorial rooms.

RMDIFF(1,1) = The number of rooms required in size interval one for the first simulation period.

While this is a relatively simple method of calculating costs, it yields a reasonable initial estimate of constructing lecture room space. Eventually the requirements for lecture rooms, offices, laboratories, and associated service areas will be summed to assist architects in designing and determining the size of a new academic building. During the initial planning stages, improved cost models for the various types of space will enable planners to evaluate if a building near the campus can be rented or purchased and converted into lecture rooms, offices, and laboratories more economically than constructing new facilities. As mentioned in Section VI the construction cost information is useful in estimating the relative savings expected for different space planning decisions.

III CALCULATING AND FORECASTING SPACE REQUIREMENTS

Many interesting techniques for planning instructional facilities on a short and long term basis have evolved from the myriad of universities in United States and Canada. The sophistication of these techniques depends on a number of factors including the institution's policies and goals, managerial talent, size and complexity of the physical plant, available monetary resources, and the urgency of space problems. To illustrate some popular and current approaches, the space planning methodology of three institutions is considered. The merits and difficiencies of their methods are examined rationally and in relation to the particular problems of the University of Toronto. Finally, the objectives and concepts of the lecture room space planning model developed for the University of Toronto are described.

III.1 University of Alberta

The University of Alberta in Edmonton has developed a long range academic plan to explore the implications of an enrollment ceiling of approximately 18,000 students, established by the provincial government.(17) The University's Academic Planning Committee has divided the enrollment into forecasted quotas for each faculty and school. To calculate the space required for its academic plan, the concept of weekly student hours (WSH) was introduced. One WSH is defined as the workload resulting from one student attending a course that meets one hour per week for the whole of the academic session. The WSH values for the quota enrollment in the various faculties and schools were projected. A set of "net unit-area allowances" were produced by site and space consultants to convert the WSH projections into the number of square feet of space of different types (i.e. classrooms, laboratories, offices, service areas) required by a department or division. The projections of net square feet for the 18,000 full time students are made by combining the net unit-area allowances with the WSH values, and information on full time faculty enrollment and staff size. Several different ratios are employed to convert net square feet to gross square feet required.

The Board of Governors of the University believe the estimates of space needs should be reasonably accurate, within 10 percent or so. While this accuracy is probably the best that can be expected in planning buildings on any campus, the precise size, type, and number of classrooms, offices and laboratories is not given. The estimates of space needs calculated using net unit-area allowances cannot expect to be accurate if the mix of students in faculties change, or lecture and laboratory scheduling efficiency is increased, or the University teaching week is lengthened, or pedagogical methods in the various disciplines change. The importance of evaluating alternative space decisions and investigating increased utilization of the existing physical plant appears to have been underreckoned.

III.2 University of Guelph

The University of Guelph generates an institutional enrollment prognostication which is reviewed by the college or faculty deans to determine projections for these smaller units.

Next the department heads review the faculty projections and project student enrollment in the various disciplines and in the specific subjects of that discipline. Subject by subject projections are forecasted for a period of usually five years. In addition, the department heads indicate the class sizes desired, number of subject sections, and the number of meeting periods per week for each section. The rather extensive amounts of data are analyzed and tabulated using punched cards and data processing equipment. The departmental summaries of total hours required per week in classrooms and laboratories of each size and type are then produced.

To convert the number of hours required by a department into classrooms and laboratories, the University of Guelph has adopted a planning standard of 28 hours per week daytime use for classrooms (at 67 percent station occupancy) and 20 hours per week for laboratories (80 percent station occupancy). The utilization rates are divided into the departmental weekly hour totals to obtain the number and size of classrooms and laboratories necessary to support the projected academic programs. Faculty and administrative staff, office space, residence space, physical education facilities, et cetera, are also calculated. The space requirements are then compared with available space to expose space deficiencies and assist in planning new construction or renovation. The University of Guelph has taken a physical inventory of all significant spaces on campus to facilitate this comparison.

Refraining from further detail on the Guelph system (References 6 and 15), it is clear their approach is the ultimate one for achieving sound management and planning of the University's facilities. Unfortunately, the University of Toronto is several times the size of the University of Guelph and at present unable to collect or cope with the detailed information required by the exactness of the Guelph methodology. The system for planning lecture facilities described in this thesis is a compromise between the detailed projections of the University of Guelph and the simple projection of net square feet, but the philosophies of the University of Guelph study have been retained.

III.3 University of Wisconsin

A detailed and excellent study was completed in December, 1966, at the University of Wisconsin for the United States Office of Education titled "A Methodology for Determining Future Physical Facilities Requirements for Institutions of Higher Education." (18) The methodology described in the report is portrayed in Figure III-1. The figure shows the relationships of a complete planning system for the many types of space. To predict classroom requirements, the investigators projected full time equivalent (FTE) enrollment and the number of weekly student contact hours (SCH) generated when the FTE enrollment is distributed into the various courses and departments. The number of square feet of classroom space required is calculated by applying a space factor as shown in Figure III-2. The University of Wisconsin uses .70 square feet/SCH which is a comparable factor to other institutions which plan in the same manner (e.g. University of Minnesota (3) -.75 square feet/SCH.). The Wisconsin methodology is similar to the

METHODOLOGY FOR DETERMINING
PHYSICAL FACILITIES REQUIREMENTS

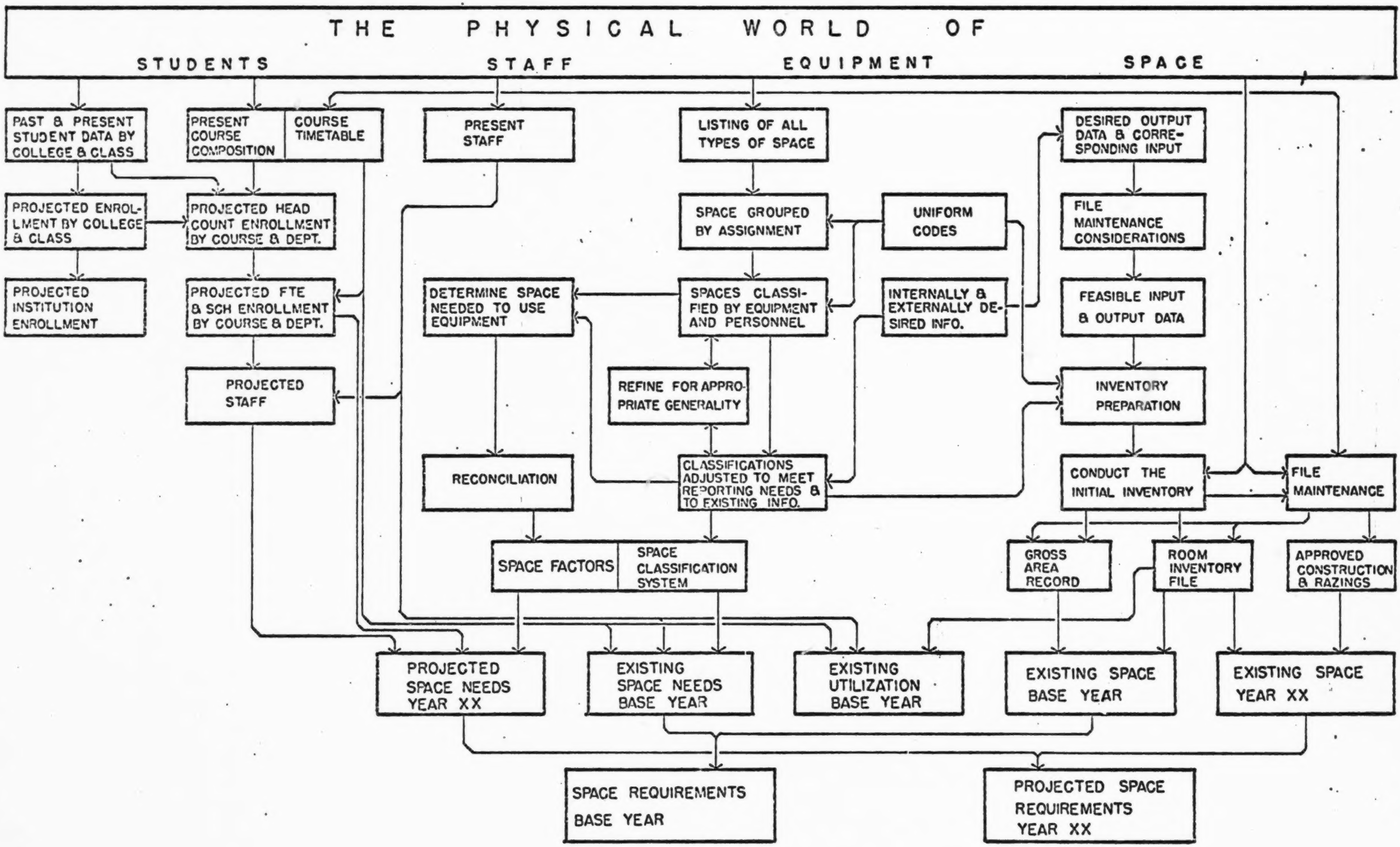
THE PHYSICAL WORLD OF
STUDENTS
STAFF
EQUIPMENT
SPACE
PAST & PRESENT STUDENT DATA BY COLLEGE & CLASS
PRESENT COURSE COMPOSITION
COURSE TIMETABLE
PRESENT STAFF
LISTING OF ALL TYPES OF SPACE
DESIRED OUTPUT DATA & CORRESPONDING INPUT
PROJECTED ENROLLMENT BY COLLEGE & CLASS
PROJECTED HEAD COUNT ENROLLMENT BY COURSE & DEPT.
SPACE GROUPED BY ASSIGNMENT
UNIFORM CODES
FILE MAINTENANCE CONSIDERATIONS
PROJECTED INSTITUTION ENROLLMENT
PROJECTED FTE & SCH ENROLLMENT BY COURSE & DEPT.
DETERMINE SPACE NEEDED TO USE EQUIPMENT
SPACES CLASSIFIED BY EQUIPMENT AND PERSONNEL
INTERNALLY & EXTERNALLY DESIRED INFO.
FEASIBLE INPUT & OUTPUT DATA
PROJECTED STAFF
REFINE FOR APPROPRIATE GENERALITY
INVENTORY PREPARATION
RECONCILIATION
CLASSIFICATIONS ADJUSTED TO MEET REPORTING NEEDS & TO EXISTING INFO.
CONDUCT THE INITIAL INVENTORY
FILE MAINTENANCE
SPACE FACTORS
SPACE CLASSIFICATION SYSTEM
GROSS AREA RECORD
ROOM INVENTORY FILE
APPROVED CONSTRUCTION & RAZINGS
PROJECTED SPACE NEEDS YEAR XX
EXISTING SPACE NEEDS BASE YEAR
EXISTING UTILIZATION BASE YEAR
EXISTING SPACE BASE YEAR
EXISTING SPACE YEAR XX
SPACE REQUIREMENTS BASE YEAR
PROJECTED SPACE REQUIREMENTS YEAR XX

FIGURE III-1

```
                                          CHART EIGHT

                                  I N S T I T U T I O N   N A M E

DIV-DEPT CODE  00 0000                PROJECTED SPACE NEEDS                          PAGE NO. 145
DEPT ABBREV    SAMPLE

      STUDENT DATA                  EXISTING  PROJECTED       FACULTY DATA           EXISTING   PROJECTED
                                      1965      19XX                                   1965       19XX

FTE LOWER DIVISION                   803.0     528.0    FTE ADMINISTRATIVE STAFF       0.00       0.00
FTE UPPER DIVISION                   205.8     297.0
FTE GRADUATE                         304.0     640.0    FTE ACADEMIC STAFF           188.24     199.77

STUDENT CONTACT HOURS -- LAB       14765.0   15889.0
STUDENT CONTACT HOURS -- NON-LAB   12988.5   11798.1

                                                                                    EXISTING   PROJECTED
      SPACE CATEGORIES                       SPACE FACTORS                         SPACE NEEDS SPACE NEEDS
                                                                                      1965       19XX

  INSTRUCTIONAL LABORATORY          2.41 SQ. FT./SCH -- LAB                          35584      38292
  INSTRUCTIONAL SPECIAL LAB              NO CHANGE FROM EXISTING AREA                  230        230
  INSTRUCTIONAL LAB SERVICE        42.02 PERCENT OF INSTR. LAB & SPEC. LAB           15049      16187

  ADMINISTRATIVE OFFICE            120   SQ. FT./FTE STAFF                               0          0
  ADMINISTRATIVE OFFICE SERVICE     15   SQ. FT./FTE STAFF                               0          0

  ACADEMIC OFFICE                  120   SQ. FT./FTE STAFF                           22589      23972
  ACADEMIC OFFICE SERVICE           15   SQ. FT./FTE STAFF                            2824       2997

→ CLASSROOM                         .70 SQ. FT./SCH -- NON-LAB                       9092       8259
  CLASSROOM SERVICE                 .05 SQ. FT./SCH -- NON-LAB                        649        590
```

FIGURE III-2

University of Alberta's academic plan (i.e. WSH are equivalent to SCH) but the Wisconsin study stresses the importance of building and maintaining a detailed inventory of available physical facilities for comparison with the calculated space requirements.

While the methodology of Figure III-1 is sound, the projected space needs are expressed in total square footage only with no disaggregation to the number of classrooms of different sizes required. Without this additional information, an architect designing a new academic building could include, say, three or four large lecture theatres, whereas several seminar rooms would more appropriately suit the class sizes desired by the departments about to occupy the building. Such an error would be very costly to rectify.

III.4 University of Toronto

To calculate lecture room space requirements at the University of Toronto a new approach was developed incorporating the following two basic objectives:

(i) Predict the number of rooms required of several different sizes.

(ii) Work at the level of detail provided by the CAMPUS model Enrollment Formulation section.

In this manner the sizes of rooms required by various departments are specified for space planners, and by applying space factors the aggregate figure of total square footage required at the University can be generated.

The forecasted information from the Enrollment Formulation section is contained in three arrays described under Section II - RØLEES, STR, and HL. The array STR provides the average class size for each academic year of each department. Some departments at the University (e.g. School of Architecture) do not teach courses to students other than those in their own department. The average class size for these departments, therefore, indicates the size of room required. However, other departments (predominantly those in the Faculty of Arts and Science) instruct students of several other departments, and as a consequence the average class size indicated is meaningless for planning purposes considering the mix of different class sizes. To calculate space requirements for both these cases, two different methods are used.

Method I is shown in Figure III-3. The total number of enrollees forecasted is divided by the average class size to yield the number of sections required. The number of weekly hours of instruction is computed by multiplying the number of sections times the average number of hours/week for a lecture subject. This requirement for room-hours is then inserted into a class size interval determined by the average class size.

Method II is displayed in Figure III-4. This method is employed when the class sizes are different for each subject taught such as is shown for the second honours year of the Political Science and Economics department. The weighted average class size is not useful for indicating the size of room required in this instance. Instead, a distribution carried in the array DIST indicates what proportion of the enrollees can

METHOD I

- For calculation of space requirements when class sizes are the same.

Example: Fourth year Dentistry. Source (14) Pg. 148.

Subject Name	No. of Sections	No. of Students	No. of Weekly Hours
Dental Public Health	1	121	1
Oral Surgery	1	121	1
Orthodontics	1	121	1
Periodontics	1	121	1
Preventive Dentistry	1	121	1
Prosthodontics	1	121	1
Operative Dentistry	1	121	1
	7	847	7

Values carried in the three arrays for fourth year Dentistry:

ROLEES = 847.0
STR = 121.0
HL = 1.0

Number of sections = $\frac{847.0}{121.0}$ = 7.0

Number of room-hours required = 7.0x1.0 = 7.0

Size of room required = 121 seats (i.e. a room of size interval 100-180)

Figure III-3

METHOD II

- For calculation of space requirements when class sizes vary.

Example: Second Year Honours Political Science and Economics. Source (14) Pp. 122-124.

Subject Name	A No. of Sections	B No. of Students	No.of Weekly Hours	Section Size (A/B)
Accounting 220	1	81	2	81
Economics 220	3	224	9	75
Economics 221	1	108	3	108
Economics 222	1	79	3	79
Economics 223	1	41	3	41
Economics 224	2	189	6	95
Economics 2720	4	482	8	120
Economics 20	1	100	2	100
Political Science 220	2	120	6	60
Political Science 221	1	185	3	185
	17	1609	45	Weighted average = 95.

Values carried in the three arrays from the Enrollment Formulation section.

ROLEES = 1609.0
STR = 95.0
HL = 45./17. = 2.65

i		C_i	D_i	E_i	F_i	
	Room Size (Students)	Interval Mid-points	Enrollee Distribution DIST	No. of Enrollees $1609.0 \times D_i$	No. of Sections E_i/C_i	No. of Room hours $F_i \times 2.65$
1.	0-20	10	0.0%	0.0	0.0	0.0
2.	20-60	40	2.5%	41.0	1.03	2.73
3.	60-100	80	43.1%	693.0	8.66	22.95
4.	100-180	140	42.9%	690.0	4.93	13.08
5.	180 up	250	11.5%	185.0	.74	1.96

Figure III-4

be expected to require classrooms of each of the five chosen size ranges. As shown, the total number of enrollees predicted is multiplied by D_i to yield the number of enrollees by size interval. To determine the approximate number of sections that would have to be taught, the mid-points of the room size intervals were selected as a standard class size and divided into E_i. Finally, the number of room-hours per week is computed by multiplying the number of sections by the average number of weekly hours per lecture subject.

The computer program decides which method will be used by checking the value of the array ITEST for the particular department and academic year being considered.

The number of hours required in rooms of each size, whether generated by method I or II, are summed for each academic year to obtain the department total. The department totals are added to produce a University wide report. The conversion from the number of room-hours into the number of rooms required by a department is accomplished by dividing by the departmental teaching week length (hours) and by the departmental room utilization (percent).

Occasionally very few (one to five) students are enrolled in a particular subject (especially graduate courses), and the professor may find it more expedient to teach classes in his own office rather than scheduling a tutorial room. Accordingly, the tutorial room requirements (size interval 0-20) will be reduced by a certain percentage (AMT0FF) to account for this facet of reality. In addition, if a department requires a tutorial room(s) for special lectures, conferences, and other purposes above its teaching needs (specified by ASSIGN), that department's tutorial room requirements are increased.

The calculations described in this section are illustrated on the 'Classroom Requirements - Model Worksheet' of Section VI, Part II. Simple hand calculations may be done on the chart for a full understanding of how the forecasts of the number and sizes of rooms required are computed each simulation period. The flowcharts and listing of subroutine ORCAST, which contains the Fortran language computer instructions for calculating classroom requirements, can be examined in Appendix B. The forecasted requirements generated by subroutine ORCAST are summarized in the departmental and faculty reports produced by the main program, and are passed along as input to subroutines UWIDE, MATCH, and SEARCH which match these requirements against the available lecture room space.

IV AVAILABLE LECTURE ROOM FACILITIES

Subroutine FACIL

For proper planning and control of new lecture room construction, university space planners require detailed information concerning the facilities currently available. In addition, some flexibility is needed in order to evaluate the effect of different construction and renovation programs on the overall University of Toronto lecture room resources in the future. Subroutine ORCAST generates forecasts of the number and sizes of rooms necessary for each department for the next several years. A matching of these departmental requirements with the space available near the departments (explained under the description of subroutines MATCH and SEARCH in Section V) draws attention to the departments with the most crucial space needs. An examination of the computer output of subroutine FACIL (along with information from the other subroutines) will assist planners in relocating a department near lecture rooms more suited to its desired class sizes, or indicate which rooms might be renovated or divided, or if new construction is inevitable, specify the number and sizes of lecture rooms the architect should include in the building. The program listing, overall flowchart, and detailed flowchart for this subroutine are contained in Appendix B. Figures 14 and 15 of Section VI, Part III, show the reports produced by Subroutine FACIL.

The data for the calculations of this subroutine are supplied in the form of a card deck as shown in Figure IV-1.

FORMAT OF CLASSROOM DATA CARDS

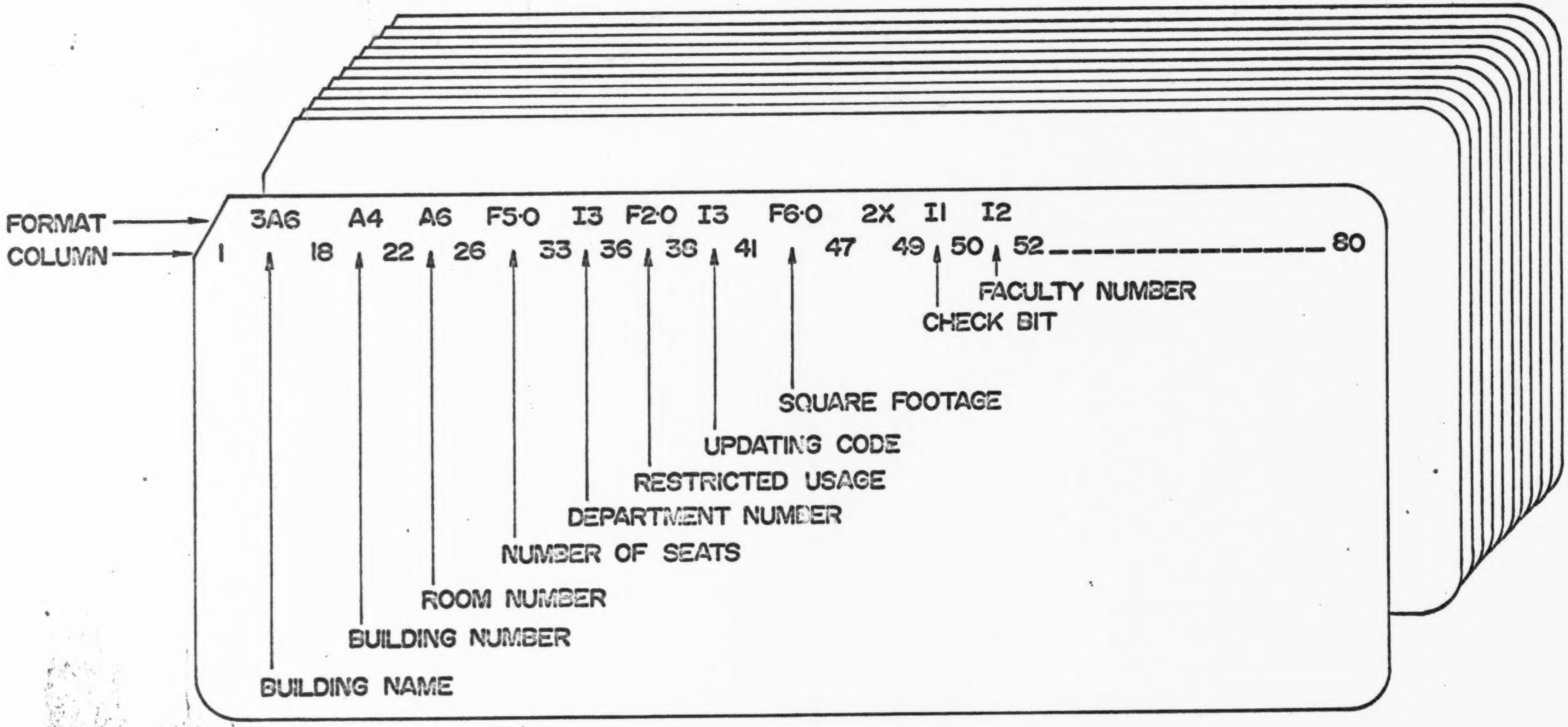
FORMAT
COLUMN
3A6
A4
A6
F5·0
I3
F2·0
I3
F6·0
2X
I1
I2
1
18
22
26
33
36
38
41
47
49
50
52
80
FACULTY NUMBER
CHECK BIT
SQUARE FOOTAGE
UPDATING CODE
RESTRICTED USAGE
DEPARTMENT NUMBER
NUMBER OF SEATS
ROOM NUMBER
BUILDING NUMBER
BUILDING NAME

Figure IV—1

One card is read for each existing or proposed lecture, seminar, and tutorial room. The specifications on existing classrooms are obtained from a magnetic tape file containing all the rooms in the University of Toronto's physical plant. Proposed classrooms can be included in the data deck by periodically checking Physical Plant Department drawings of future buildings. The precise meaning of each of the variables describing a room is outlined below.

The building name (BLDG), and the building number (NBLDG) identify the location of the room on campus (see list of Physical Plant Departments' codes for major academic buildings - Appendix A).

The room number (NROOM) is the number on the door of the room, and if the room has two differently numbered doors, generally the lower number is used.

The number of seats in the room (SEATS) is simply the sum of the seats bolted to the floor. However, where moveable seats are present and often shifted about among rooms, the proper number of seats becomes the number the room will reasonably hold without overcrowding.

If a room has been assigned for the exclusive use of a department by Central Room Allocation, that department's number (NODEPT) is placed in columns 34 to 36; otherwise the department number is zero.

Some lecture and seminar rooms (particularly those with tables and chairs) are used part of the time as conference rooms, computation laboratories, etc. The number of weekly hours (NRES) that the room is utilized for these special purposes is contained in columns 37 and 38 of the data card. There are few multi-function rooms now, but the ability to recognize the part-time use of a room for lectures is important considering the trend towards multi-function space - e.g. the combination laboratory-lecture rooms designed for the University of Toronto's Scarborough College.

The updating code (NUPDTE) indicates whether a room will be included in the list of available classrooms for a particular session.

The square footage (SQFT) is the area of the room in square feet as measured by the Physical Plant Department.

The room assignment check bit of column 50 is explained later in the description of the operation of subroutines MATCH and SEARCH.

The final field on the data card contains the number of the faculty (NFAC) in whose jurisdiction the room lies. A report of the lecture rooms available for each Faculty (or School or College) could be generated if room scheduling were done by each Faculty.

The classroom data deck was prepared from a lecture room facilities report composed by the Department of Statistics and Records and is listed in Appendix C, pages 1-5.

Subroutine FACIL compiles and prints a list of the classrooms available during each simulation period by examining the room updating code of each room in the data deck. The updating code comprises three digits, the latter two digits indicating a year number. If the Physical Plant Department is planning to rent, buy, or construct additional lecture room space, the first digit of the updating code is one. For example, if a room updating code of 169 is specified, the program adds this room to the list of available lecture rooms in the session 1969-1970. Similarly, if a building is scheduled for demolition or sale in, say, session 1970-71, the lecture rooms in that building carry an updating code of 270. Occasionally lecture rooms are renovated to improve lighting, blackboards, et cetera. The assumption is made that lecture room renovation does not take longer than one academic session; therefore the program temporarily removes a room from the lecture room inventory for a session when an updating code beginning with three (e.g. 368) is found. A room updating code of 000 indicates no plans exist to change the status of that room.

The partial list of rooms for session 1967-68, shown in Figure 14 of Section VI, is self explanatory except for the last column. As a measure of the utilization of lecture room space, the number of square feet per seat for each room in the University is calculated and averaged over all rooms. The deviation of the number of square feet per seat for each room from the average is reported in the last column of the computer printout. This information enables one to pinpoint space that is not well utilized assuming the average value as a standard. Subroutine FACIL also computes some statistics of interest to space administrators for the lecture rooms of each room size range. Figure 15 of Section VI summarizes the number of rooms, seats, room-hours, and square feet available in classrooms of each different capacity range. The average number of square feet per seat for rooms of each size range is calculated, and as might be expected, the value of 16.9 square feet per seat for tutorial rooms is much higher than the large lecture theatres because of the higher percentage of aisle space in a small room. The mean room size for the available rooms in each size interval is also printed on the report. Both the mean room size and the average number of square feet per seat are used in calculating the cost of new lecture room facilities.

The information on available space generated by subroutine FACIL is passed on to other subroutines of the computer program which compare requirements for rooms against the available lecture rooms.

V MATCHING REQUIRED SPACE AGAINST AVAILABLE SPACE

Once the departmental lecture room space requirements have been generated, the next step in the planning process is a comparison against available facilities for the particular point in time. Answers must be obtained for important questions which arise:

(i) how much of the required space exists already.

(ii) are the correct sizes and types of space located near departments requiring this space.

(iii) can a shortage of space be rectified by conversion of some underutilized existing space to a new function.

(iv) how much space must be obtained from new construction or rental of nearby space.

(v) what will the acquisition of space cost.

The computer program sums the space requirements of all departments and compares them against the University's lecture room facilities. The ensuing report indicates aggregate shortages or surpluses in terms of room-hours and number of rooms. Further departmental reports are produced to show the adequacy of classrooms near that department for fulfilling its needs. The reports and analyses that assist in answering the above questions are explained in the following sub-sections.

V.1 University-wide Level

The university-wide matching report for lecture room facilities is shown in Figure 1 of Section VI. Such a report is generated for each term or session simulated. The information and the report are produced by subroutine

UWIDE (refer to listing and flowcharts in Appendix B) after the departmental requirements and room availabilities are ascertained. For each room size interval, the total shortage or surplus of room-hours and rooms are shown.

First consider the upper section of the report for rooms. The difference between the total number of rooms available and the total number of rooms required is calculated. A negative differential indicates a shortage of rooms of that size; a positive differential indicates an overage. As mentioned in Section VI, the aggregate implications of different policy decisions on lecture rooms may be indicated on the report. The five room size intervals should be treated as unique room planning intervals; however, it may be more desirable to employ larger rooms to satisfy a shortage in the smaller size intervals than to construct several small classrooms. Naturally, if not sufficient classrooms of the largest size are available, the only resorts are to construct the required number of rooms, or reduce section sizes which involves costs in providing additional staff and office space. Subroutine UWIDE evaluates whether a room shortage in a size interval can be fulfilled by a surplus of rooms in size intervals above that interval. Refer to Figure 1 of Section VI for illustration of this point. The shortage of 31.3 tutorial type rooms of the first size interval (0-20 students) can be satisfied by 5.4 rooms of the second size interval, 25.6 rooms of the third, and 0.3 rooms of the fourth size interval. In the real system this amounts to scheduling classes of size 0 to 20 students in the larger rooms. The percentage of seats occupied will drop, but the costs of underutilizing the space may be less than the construction of new facilities. The actual overage or underage of lecture rooms of each size range after the matching process is shown in the centre of the page. In this instance the University has a surplus of 18.0 rooms of the fourth interval and a surplus of 16.1 lecture theatres.

A further possible means of fulfilling lecture room shortages is to subdivide or join rooms. For example, suppose we required two rooms of size 0 to 20 students and had one extra room of size 20-60 available; the extra room could probably be partitioned to provide two rooms of size 0 to 20, thus fulfilling the shortage. Similarly a shortage of, say, one room of size 100 to 180 students could be satisfied by removing a wall between two adjoining rooms of capacity 60 to 100 to form the larger room. The computer program does not manipulate the information on Figure 1 to evaluate this possibility. However, the analysis of available space provided by subroutine FACIL and architectural surveys may indicate to space planners where conversion or renovation of existing facilities is feasible to fulfill classroom shortages in this manner.

The lower part of the university-wide report outlines the number of hours required in classrooms of each size range. The total room-hours in the 'Required' column is a summation of the room-hour requirements of the forty-seven academic departments. The total number of room-hours in the 'Available' column is established by considering each of the existing classrooms available for thirty-five hours (the average teaching week for the University) less any hours restricted for special purposes beyond departmental lectures. These two columns are matched to yield any excess or shortage of room-hours, as shown in the 'Differential' column of Figure 1 of Section VI. The room utilization or the percent utilization of the weekly available room-hours is now calculated. Illustrating from Figure 1 for the first size interval:

$$\text{Room utilization} = \frac{X}{Y} \times 100\% = \frac{2213.2}{1855.0} \times 100 = 119.3\%$$

where X = required number of room-hours
Y = available number of room-hours

Obviously a utilization this high cannot be reached. In fact the maximum expected room utilization at the University of Toronto with the existing scheduling sophistication is about 60%. Few universities have a utilization appreciably higher than ours because of the complexities and difficulties of time-tabling. Our calculated room utilization is 119.3 - 60.0 = 59.3% above the utilization that Central Room Allocation can reasonably expect to attain. This value is shown in the 'Deviation from Expected Utilization' column. Therefore, the available number of room-hours must be adjusted by an index which reflects the utilization differential, namely:

$$\frac{119.3\%}{60\%} = 1.99$$

The actual number of room-hours required to satisfy demand becomes

$$1855.0 \times 1.99 = 3688.6 \text{ room-hours.}$$

The expected shortage of room-hours is

$$3688.6 - 1855.0 = 1833.6 \text{ room-hours.}$$

This shortage is reported as a negative value in the 'Expected

Overage or Underage' column. The deficit of 1833.6 room-hours is much higher than the shortage of 358.2 room-hours indicated by a straight matching of requirements and availabilities. Similarly for the second, third, fourth, and fifth size intervals on Figure 1 of Section VI, the expected excess number of room-hours is less than shown under the 'Differential' column because the University of Toronto can only schedule to a room utilization of 60%.

The expected surplus or shortage of room-hours can be converted into a surplus or shortage of rooms of each size interval by dividing by the length of the University teaching week (35.0 hours in our example report). However, the 'Differential' column for rooms on Figure 1 of Section VI does not correspond completely to the number of rooms calculated from the 'Expected Overage or Underage' column. The required number of rooms in the size range 0 to 20 students is reduced slightly by the parameters AMTOFF and ASSIGN as described under Section III.4.

To complement the planning information displayed on the university-wide matching report, an analysis of each department's space needs is undertaken. The departmental matching process is described below.

V.2 Departmental Level

The matching of available lecture room facilities to requirements for space at the departmental level is controlled by subroutines MATCH and SEARCH. Basically, the routines examine the rooms available in buildings near each department's academic and administrative offices, then following certain rules and restrictions select appropriate rooms to fulfill departmental requirements, and finally compute and print information on the matching process. The flowcharts and program listings for subroutines MATCH and SEARCH are contained in Appendix B.

Before describing the matching procedure it is useful to review the form of each department's room requirements. A distribution of the number of rooms required in each of the five chosen size intervals is supplied as input data to subroutine MATCH. In addition, for each department and every size interval the weighted average of the class sizes taught per week is computed. These weighted averages are stored in the array AVGISS (IDPT, INTRVL) and indicate the capacity of room that should be chosen in each size interval to satisfy a department's room requirements. Since the departmental requirements are forecasted in five unique room size ranges, subroutine MATCH endeavours to satisfy the requirements of all departments for the first size interval, then loops back and repeats the process for the next size interval, and so on. Thus the following description of the operation of subroutines MATCH and SEARCH for one size interval applies to the matching of rooms in all size intervals.

In order to properly evaluate how adequately the myriad of room sizes on this campus satisfy the requirements of departments located in buildings scattered over the campus, the following procedures were programmed into the model:

1. The departmental requirements are matched sequentially (in the order of the list of departments in Appendix A).
2. The program tries to satisfy whole number room requirements only. For example, if a department requires 3.3 rooms of a certain size per week, three rooms would be matched from the available facilities. The treatment of fractional room requirements will be discussed subsequently.
3. Only one room at a time is matched in order to prevent a department from fulfilling its requirements while another department is unable to find rooms. In other words, if two or three departments are housed in the same building, before a second room is assigned to one of the departments, a search for one room for each department (requiring at least one room) must have been completed.
4. The list of five buildings (the array BLDPRI) is searched in order from the first building to the fifth. Generally the first building contains the department's offices and staff, and the remaining buildings are closest geographically to the first.
5. The fifth building on the list is specified as ZERO for all departments. The ZERO indicates to the program to search for any remaining rooms in the University rather than in a particular building. The user has the option of selecting this feature by setting the parameter NPRIOR.
6. The buildings of second, third, fourth, and fifth priority on a department's list are not examined until the second, third, fourth, and fifth iterations respectively through all the departments. The program always starts at the

first building on the list.

7. If the room requirements of all departments in a size interval have been matched, the program transfers to the next room size interval.
8. A count of the number of rooms matched in a size interval is maintained. If this count equals the number of rooms available, the program transfers to the next size interval.

The matching procedure described above is shown in the flowchart of Figure V-1.

When subroutine MATCH calls subroutine SEARCH to find a suitable room, the following arguments are supplied in the calling statement:

INTRVL,IJ - these indices identify the particular room size range under concern.

IDPT - the department number.

ICOUNT - a building counter.

FOUND - an indicator as to whether a room has been located.

ITERAT - searching iteration number.

A search is conducted in the buildings on the list of the department indicated for a room in the size interval specified. The overall flowchart for subroutine SEARCH, contained in Appendix B, portrays the searching operation. The goal of this module is to ascertain if any room in the size interval is available near the department's academic offices. This goal is based on the assumption that students and staff should not have to venture back and forth across campus for their lectures. As an aid in determining which room in an interval is most appropriate, the weighted average class size is employed

MATCHING PROCEDURE FOR ROOMS
OF A PARTICULAR SIZE INTERVAL

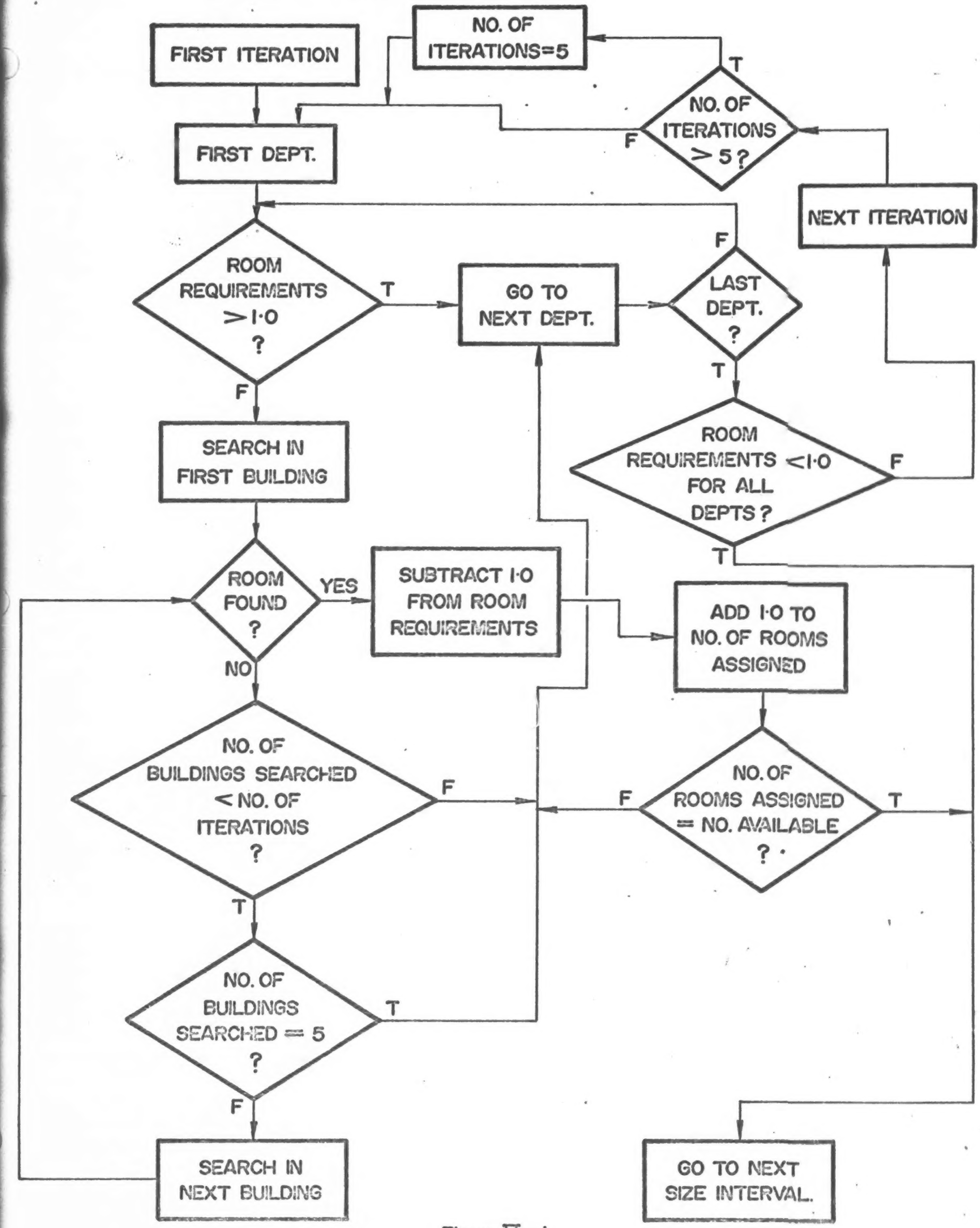
FIRST ITERATION
NO. OF ITERATIONS=5
T
NO. OF ITERATIONS > 5 ?
F
FIRST DEPT.
NEXT ITERATION
F
ROOM REQUIREMENTS > 1·0 ?
T
GO TO NEXT DEPT.
LAST DEPT. ?
T
F
SEARCH IN FIRST BUILDING
ROOM REQUIREMENTS < 1·0 FOR ALL DEPTS ?
F
T
ROOM FOUND ?
YES
SUBTRACT 1·0 FROM ROOM REQUIREMENTS
ADD 1·0 TO NO. OF ROOMS ASSIGNED
NO
NO. OF BUILDINGS SEARCHED < NO. OF ITERATIONS ?
F
F
NO. OF ROOMS ASSIGNED = NO. AVAILABLE ?
T
T
NO. OF BUILDINGS SEARCHED = 5 ?
T
F
SEARCH IN NEXT BUILDING
GO TO NEXT SIZE INTERVAL.

Figure V-1

in a calculation of the seat utilization that may be expected in a room. The search proceeds as follows:

1. Examine the list of available lecture room facilities sequentially until the particular building being searched is found.
2. For lecture rooms that are available on a full time basis (i.e. NRES = 0.0) and have not been assigned to a department on a previous search (i.e. LCHECK = 0), compute a value of seat utilization by dividing the average class size by the capacity of the rooms.
3. From the group of possible rooms select the one in that interval that has a computed seat utilization less than or equal to 100% but closest to 100%; otherwise choose the room with a seat utilization above 100% and closest to 100%.
4. If a suitable room is found, store the value of seat utilization computed, set FOUND = 1.0, and tag that room as assigned (LCHECK = 1) to the department under consideration (LODEPT = IDPT).
5. If a room is not found, FOUND is set equal to 0.0.
6. Program control is transferred back to subroutine MATCH.

An important point to recognize here is that the seat utilization value calculated by subroutine SEARCH is not the same as the usual concept of seat utilization, i.e. the number of seats occupied during a lecture as a percentage of the seats available in the room. Without enrollment forecasts at the subject level, we cannot compute the seat occupancy

SAMPLE DISTRIBUTION OF CLASS SIZES
ROOM SIZE RANGE 60—100

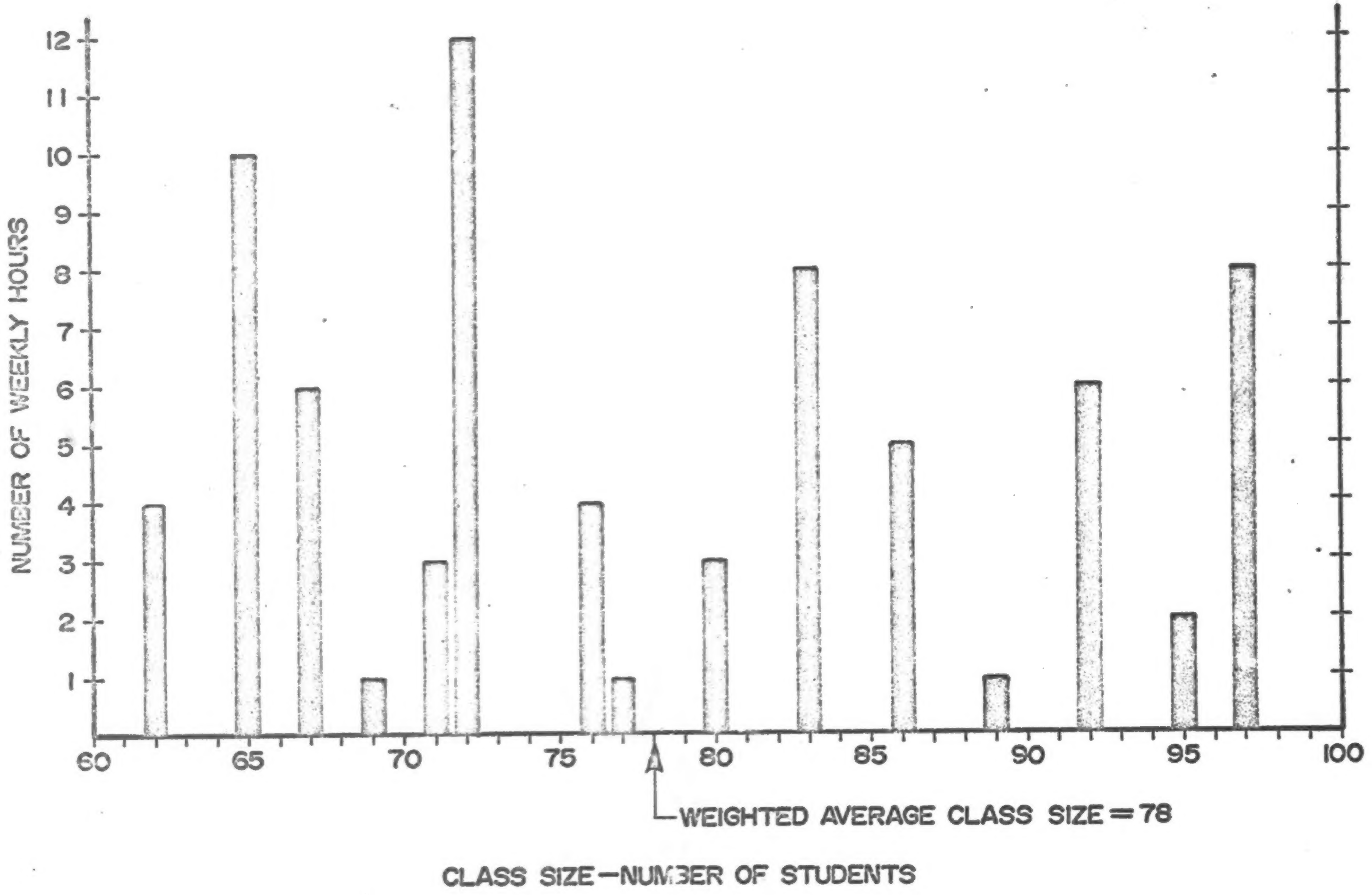

Figure V—2

of a room. Figure V-2 shows a typical departmental distribution of class sizes in the room size range 60-100 students. By weighting by the number of hours per week that a particular class size is taught, we can determine the average class size of 78 students for this interval. The capacities of selected lecture rooms are compared to this average and seat utilizations computed (some of which may be greater than 100%). A room of size 78 or greater (i.e. computed seat utilization less than or equal to 100%) would be chosen for this department; only if no such room exists, is a smaller room than 78 seats (i.e. computed seat utilization greater than 100%) selected. By this procedure, we can expect a high seat occupancy for departmental classes that will fit in the room, and the best match of a lecture room requirement in the size interval 60 to 100 to the available rooms. In the real system, class sizes that are too large for the room selected will be scheduled in a larger lecture room. It can be seen from Figure V-2 that in the limit as room capacity approaches 100 students, 100% of the class sizes taught by this typical department could be scheduled in the room. However, the percentage of class sizes that will fit in a room of capacity less than 100 students cannot be calculated because of the lack of subject by subject enrollment forecasts. Consequently, this program is limited to matching a room requirement to any room in the size interval. The use of the departmental weighed average class sizes enables the program to distribute rooms of many different sizes to the departments best suited for these room sizes. The matching information generated is therefore more meaningful using the weighted average class size factor.

A sample departmental report showing the planning information provided can be found in Section VI - Figure 7. The requirements for the Department of Zoology are stated in terms of the number of room-hours and the number of rooms in each size interval. The effect of varying the parameters shown is explained in Section VI. Subroutines MATCH and SEARCH have found three rooms to match the three (whole number) rooms required. Observe that a room of size 98 students was located in Sidney Smith Hall juxtaposed to Zoology's home building - Ramsay Wright Laboratories. This information indicates first, that a room of size 60 to 100 students was not included in the planning of the building even though 27.6 teaching-hours per week involve class sizes of this range, and second, Central Room Allocation may schedule these lecture room-hour requirements in Sidney Smith Hall. The seat utilization values specified on the report are the computed values explained previously. Any unsatisfied room requirements after the matching process are reported. However, in our example report only fractional requirements are remaining.

On completion of the lecture room matching process for all departments, subroutine MATCH calculates and prints information on the utilization of space and the effectiveness of the match. A listing of the rooms remaining in a central pool of rooms, and sub-totals of the number of rooms and the number of seats unmatched in each size interval is printed in the format shown in Figures 16 and 17 of Section VI. Since only whole number room requirements are matched, all departments

V

must satisfy their fractional room requirements (and any unmatched whole number room requirements) from the lecture rooms remaining in this central pool. This assumption implies students and staff may be required to travel a substantial distance for a few lectures, although realistically Central Room Allocation would endeavour to schedule these few classes geographically proximate to a department's home offices, subject further to the scheduling goal of high seat occupancy. The total departmental unsatisfied room requirements are compared to the available central pool of rooms, and a shortage or excess calculated as shown in the 'Differential' column of Figure 17.

As a further indication of the results of the matching process the following three percentages are computed:

(i) OVERSU - As previously explained, a value of seat utilization is computed to gain a relative measure of how the room capacity suits the class sizes of a department. As a room is identified as suitable for a department, the seat utilization value for that room is stored in the computer's memory. When the matching process has been completed for all departments, the average value of seat utilization is calculated for matched rooms of each size interval. These values are then averaged to obtain the overall seat utilization OVERSU. The upper portion of the computer printout displayed in Figure V-3 shows a value of 95.0% for OVERSU.

(ii) EFFMAT - If the room sizes in a particular geographic zone on campus are not appropriate for the class sizes

```
AVERAGE SEAT UTILIZATION FOR ROOMS ASSIGNED TO INDIVIDUAL DEPARTMENTS

                SIZE(STUDENTS)          SEAT UTILIZATION

                  0. TO   20.                59.3
                 20. TO   60.               100.1
                 60. TO  100.                96.8
                100. TO  180.                88.3
                180. TO  999.               130.3

                OVERALL SEAT UTILIZATION =   95.0 PERCENT



MATCHING EFFICIENCY BY SIZE INTERVAL = NUMBER OF ROOMS MATCHED/NUMBER OF ROOMS TO BE MATCHED TIMES 100

                SIZE(STUDENTS)          MATCHING EFFICIENCY

                  0. TO   20.                65.6 PERCENT
                 20. TO   60.                70.2 PERCENT
                 60. TO  100.               100.0 PERCENT
                100. TO  180.                50.0 PERCENT
                180. TO  999.               100.0 PERCENT

             OVERALL MATCHING EFFICIENCY =   77.2 PERCENT


EFFSAT=   85.2

PERSAT=   26.0   INTERVAL= 1
PERSAT=  100.0   INTERVAL= 2
PERSAT=  100.0   INTERVAL= 3
PERSAT=  100.0   INTERVAL= 4
PERSAT=  100.0   INTERVAL= 5


SUMMAX= 257.3     MATCHING NUMBER 1     SEAT UTILIZATION = 100.0
```

FIGURE V-3

of departments in that zone, or if simply an insufficient number of rooms are available to meet departmental requirements, the computer program will be unable to match all the requirements to available facilities. For each size interval the sum of the whole number room requirements of all departments is compared to the number of rooms matched or found and a matching efficiency calculated where:

$$\text{Matching efficiency} = \frac{\text{Number of rooms matched}}{\text{Number of rooms to be matched}} \times 100\%$$

The overall matching efficiency EFFMAT is the average of the matching efficiencies by size interval. An example report is shown in the centre of Figure V-3 where EFFMAT = 77.2%.

(iii) EFFSAT - Figure 17 of Section VI shows the comparison of the total departmental unsatisfied room requirements to the available central pool of rooms. In addition to the 'Differential' column, subroutine MATCH calculates for each size range the percentage of the rooms required that are satisfied by the remaining lecture rooms, i.e.

$$\text{Percentage satisfied} = \frac{\text{Rooms remaining in the Central Pool}}{\text{Total unsatisfied room requirements}} \times 100\%$$

(If this percentage is greater than 100%, it is set equal to 100%).

The average percentage satisfied EFFSAT is calculated from the values for the five size intervals and is reported as shown in Figure V-3.

As illustrated and described in Example 5 of Part III of Section VI, we may investigate searching for a room slightly larger than the upper boundary of the size interval under consideration. For example, if we are unable to locate a room of capacity 0-20 students, we may satisfy the requirement in that interval by extending our search to include, say, rooms of capacity 0-25. The upper boundary is adjusted by multiplying by 100.0/SUTAL where SUTAL is a parameter less than or equal to 100.0 and represents the reduction in seat utilization that will be tolerated. For illustration purposes, a sample calculation is shown below where SUTAL = 80%:

	Original interval	Expanded interval
Size (students)	0 to 20	0 to $20 \times \frac{100}{80}$ or 0 to 25
Computed seat utilization (using upper boundary as a base)	$\frac{X}{20} \times 100 = 5X\%$	$\frac{X}{25} \times 100 = 4X\%$

- where X is the weighed average section size AVGISS for some department in the first size interval.

Reduction in computed seat utilization $= 100 - \frac{(5X-4X)}{5X} \times 100\%$

$= 100 - 20\%$

$= 80\%$ of the original value.

When we expand size intervals in this manner, we can expect the average seat utilization to drop for rooms matched in each interval and hence the value OVERSU to decrease. However, by employing the larger intervals subroutine SEARCH may satisfy a room requirement hitherto unfulfilled. Consequently the matching efficiency by size interval and the overall average EFFMAT will increase. The statistic EFFSAT will increase or decrease depending on the room size intervals chosen for this planning model, the class sizes desired by the academic departments, and the capacities of existing lecture rooms. From the results at the bottom of Figure 17 of Section VI, it can be seen that the unsatisfied room requirement for size interval 0 to 20 will probably decrease when larger size intervals are used because there is a surplus of rooms in the other size intervals. In turn EFFSAT will most likely increase. We hypothesize that there is an optimal value of SUTAL which, when the intervals are expanded, will produce a high value of EFFMAT and EFFSAT without an unreasonably low value of OVERSU. To test this hypothesis, the sum SUMMAX was formed where,

$$\text{SUMMAX} = \text{EFFSAT} + \text{EFFMAT} + \text{OVERSU}.$$

The value of SUMMAX is reported as shown at the bottom of Figure V-3. Each of the three percentages was weighted equally since there was no clear reason for weighting otherwise. The parameter SUTAL is varied by the computer instructions of the main program in an attempt to maximize SUMMAX. A program control parameter SSTOP described in Table I of Section VI provides the option of selecting a particular value of SUTAL or allowing the computer to run through a sequence of values. The results of some experiments performed to analyze the effects of varying SUTAL on the matching process are shown in Figure V-4 and tabulated in Figure V-5.

Figure V-4(a) indicates the best match of available rooms to requirements occurs when SUTAL = 100% or the room size intervals are unchanged. Subroutine SEARCH has examined up to

VARIATION OF SUMMAX WITH SUTAL

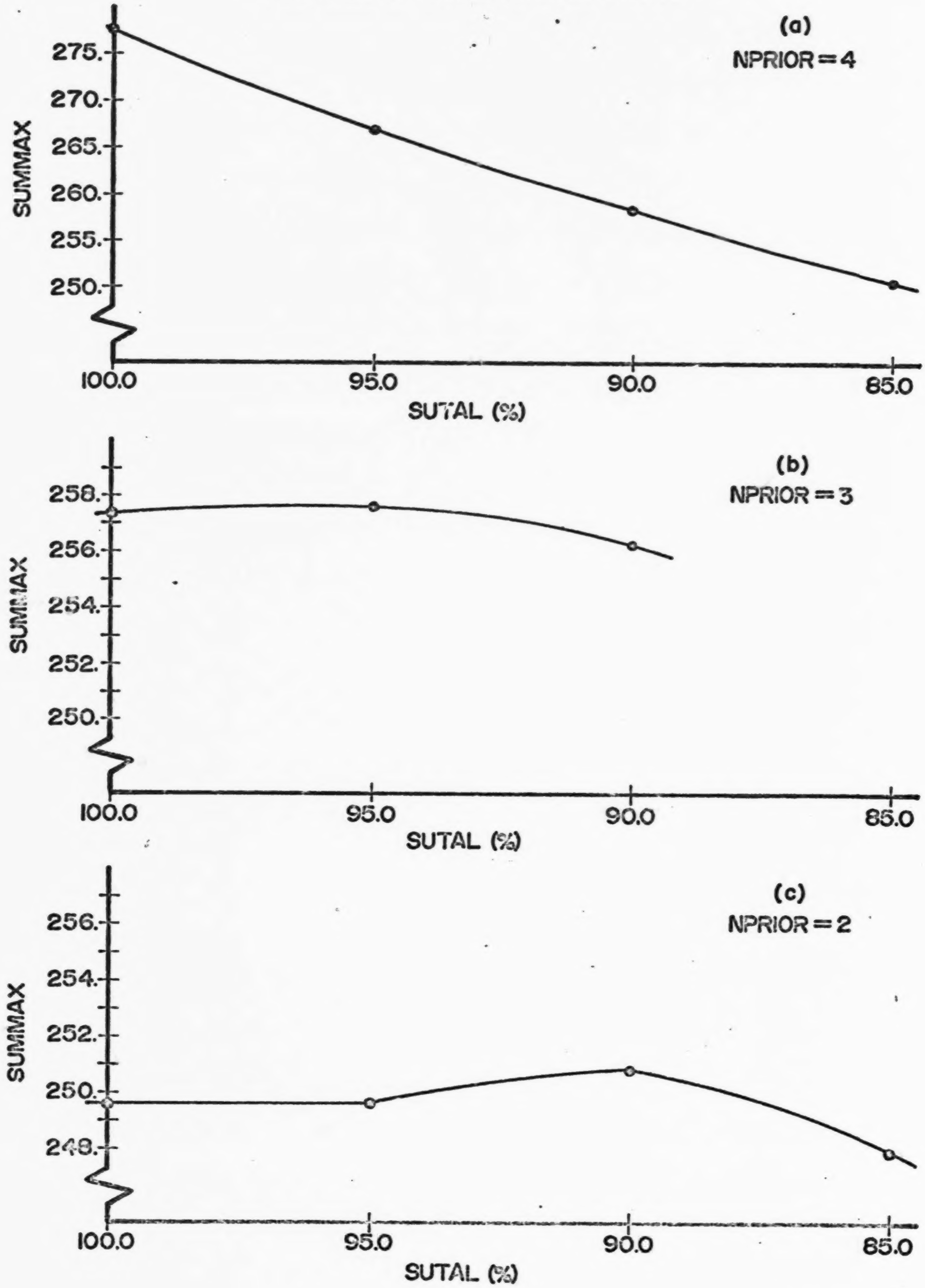

Figure V – 4

Data for Graphs Plotted in Figure V-4.

NPRIOR	SUTAL	SUMMAX	OVERSU	EFFMAT	EFFSAT
a)4	80.0	251.5	72.1	91.2	88.3
	85.0	250.7	74.0	91.0	85.7
	90.0	258.5	82.3	91.0	85.2
	95.0	267.0	94.7	87.6	84.7
	100.0	277.4	104.3	91.0	82.1
b)3	90.0	256.3	85.8	83.8	86.6
	95.0	257.6	94.3	77.2	86.1
	100.0	257.3	95.0	77.2	85.2
c)2	85.0	248.0	82.0	77.1	88.9
	90.0	250.9	85.7	76.7	88.5
	95.0	249.7	95.0	66.7	88.1
	100.0	249.7	95.8	66.7	87.3

Figure V-5

four buildings (NPRIOR = 4) in fulfilling the room requirements for each department. The matching efficiency is quite high after searching through the four buildings, so that any expansion of the room size ranges will cause the seat utilization to drop rapidly while the matching efficiency may change only slightly. This phenomenon can be seen in the tabulated values of Figure V-5(a). Very 'flat' curves resulted from the experiments performed for NPRIOR equal to 2 or 3. The maximum value of SUMMAX is obtained for a value of SUTAL less than 100%, as shown in Figure 4(b) and 4(c). When fewer buildings are searched, a department's room requirements initially may be only partially satisfied, and as the room size ranges searched are widened (i.e. SUTAL decreased) the overall matching efficiency increases to a greater degree than the drop in overall seat utilization. As the three factors OVERSU, EFFMAT, and EFFSAT are weighted equally, a reduction in SUTAL below approximately 85% causes SUMMAX to decrease rapidly since EFFMAT approaches 100% but OVERSU continues declining towards 0%.

In matching departmental room requirements to available space, space planners may run experiments as described above and in Section VI. A review of the reports produced each simulation period will assist them in evaluating the difficulties in loading projected enrollment into available lecture room facilities. As a further aid in the planning process, the final report produced by subroutine MATCH indicates the percentage of rooms matched in each building. This percentage is the proportion of rooms available in a building tagged as suitable for satisfying some department's requirements. The report is shown in Figure 13 of Section VI. A low percentage implies that the room capacities in a building do not correspond closely to the class sizes taught by departments housed in that building, and/or unmatched rooms remain in that building. The information from this report could be used in conjunction with the departmental matching reports and reports of other types of space (i.e. academic offices, laboratories, et cetera) to assist planners in relocating a department in a more suitable building on campus.

VI EXAMPLES SHOWING THE EVALUATION OF LECTURE ROOM SPACE PLANNING DECISIONS BY THE S.P.A.C.E.S. SIMULATION MODEL

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SECTION I INTRODUCTION

The C.A.M.P.U.S. simulation planning model under development at the University of Toronto provides information for the analysis of problems facing university administrators and planners.[1] One of the main sections of the C.A.M.P.U.S. model is the space requirements module. This section bears the acronym S.P.A.C.E.S. (Space Planning Analysis by Computer Evaluation and Simulation) and will contain detailed models for projecting and analyzing the requirements for lecture rooms, laboratories, academic offices, administrative offices, and the many types of supporting space (residences, eating facilities, physical education facilities, and so on). Currently SPACES consists of a detailed model for lecture room space only, although programming of the computer models for the other types has begun.

The increasing enrolment at the University of Toronto (now over 27,000 full-time and part-time students), expanding research activity, and continually changing curricula are straining the institution's limited space capacity. The University must carefully manage and utilize its existing physical plant and plan systematically for renovation of existing facilities and construction of new facilities. The lecture room space planning model described herein provides information which assists space administrators in the planning of lecture room facilities for the proliferating student body and the ever-changing mix of class sizes.

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[1] Judy, R. W. and Levine, J. B., A New Tool for Educational Administrators, University of Toronto Press, 1965.

It forecasts departmental classroom or lecture room requirements and compares the available rooms to these requirements. Various experiments can be run on the model to evaluate alternative space planning decisions.

Section II of this report contains a simplified model worksheet to help the reader to learn how the model calculates classroom requirements.

Section III describes how the requirements are compared against available lecture rooms, and illustrates the various computer reports. In addition, typical planning decisions are simulated and the results analyzed. It is hoped from this brief orientation that the reader will gain insight into the model's operation and its use, as well as an appreciation of the information to be provided by planning models for other types of space.

SECTION II SIMPLIFIED MODEL WORKSHEET

This section describes an orientation model developed to show how the computer uses the lecture room planning model to calculate classroom requirements. This orientation model is similar in structure to the orientation model illustrating the main features of C.A.M.P.U.S.[2/]; it is a revision of the classroom requirements section of that orientation model. The model worksheet of this report begins after the enrolment formulation section described in OIR-6. Like the simplified C.A.M.P.U.S. model the worksheet contains only two academic years and two departments. It is a simplified but accurate picture of how the computer model operates for all academic years of the multitude of departments at the University of Toronto. The enrollee totals and the parameter values chosen are hypothetical and for illustration purposes only. The reader may follow the worksheet and observe the sequence of calculations performed by the computer. In addition, very simple hand calculations can be performed and the results inserted.

Two methods of calculating classroom requirements are shown. The first method is illustrated by the computations for Department 1. If a particular academic year had a constant class size, one could schedule all the classroom hours required per week in a room equal to that class size. To perform the simple arithmetic, multiply or divide the variable generated by the previous

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[2/] OIR-6 Orientation Examples Showing Application of the C.A.M.P.U.S. Simulation Model. B. L. Hansen and J. G. Barron, Dec. 1966.

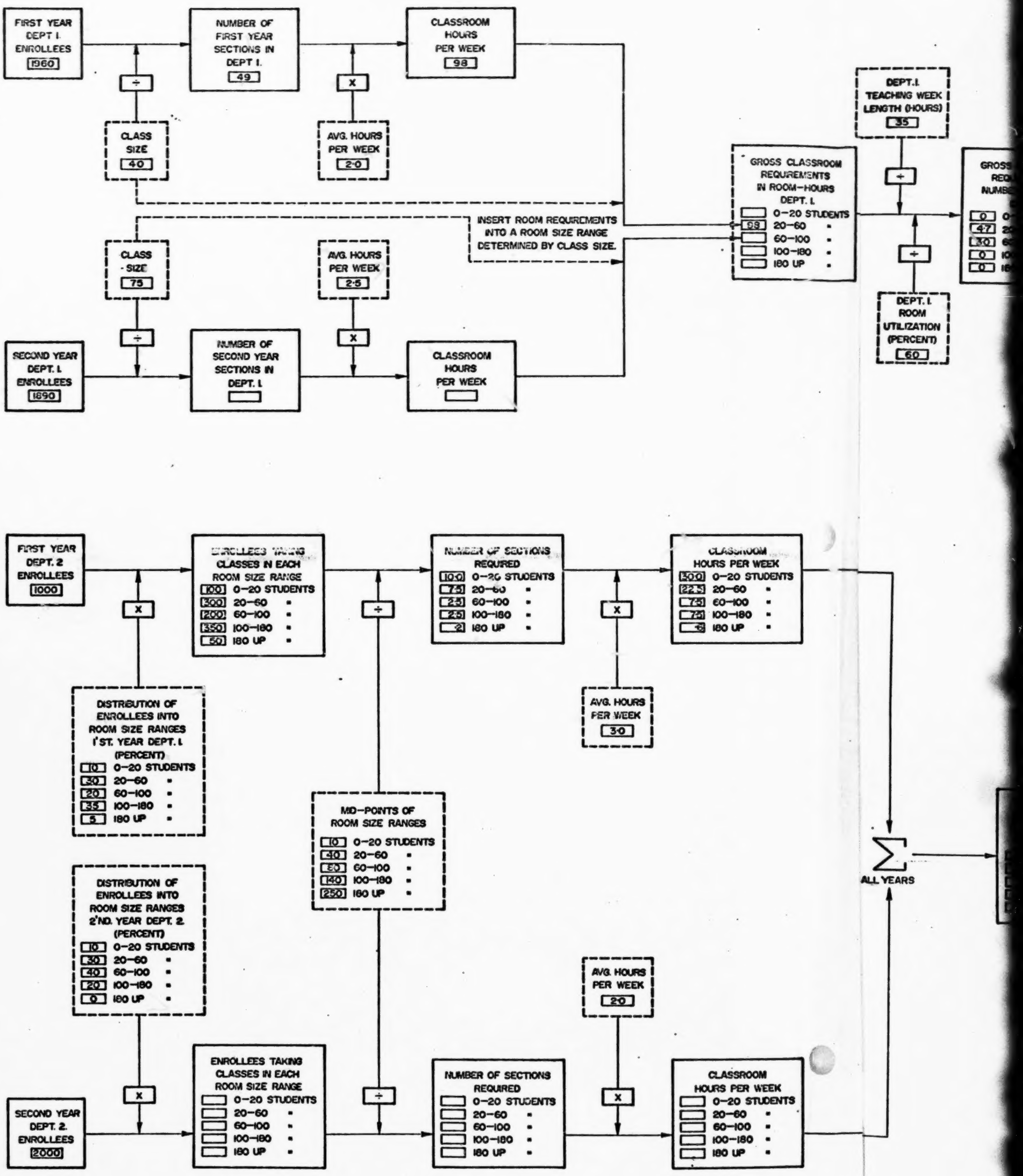
computation by the parameter in the dotted box. For example, the number of first year sections in Department 1 equals the first year enrollees[3] divided by the average class size, i.e. 1960 ÷ 40 = 49 sections.

The second and more realistic method is illustrated on the worksheet by the calculations for Department 2. For example, if there are many different class sizes taking the subjects offered in the first year by Department 2, we must break the total number of enrollees forecasted into the number of enrollees taking classes in each room size range. Dividing this result by the midpoints of the room size interval yields the number of sections in rooms of each size. The classroom hours required are then calculated by multiplying the number of sections in each room size interval by the average number of hours per week taught per subject. For both Departments 1 and 2, the number of rooms required is computed by dividing by the length of the departmental teaching-week and then by the departmental room utilization parameters. This latter value reflects the university's ability to utilize its capacity.

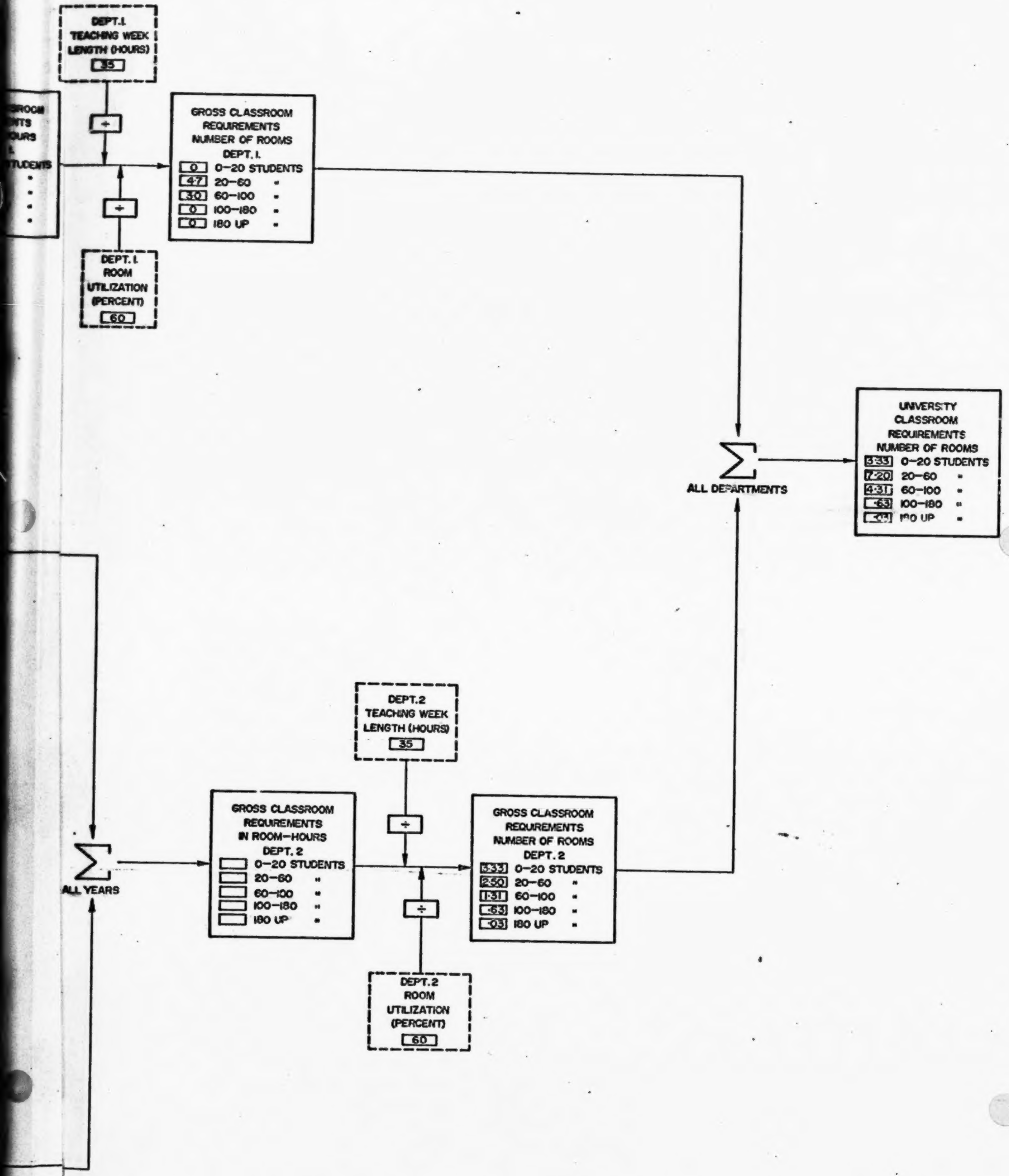
In the simplified example, the gross classroom requirements (number of rooms) have been calculated for each department and then summed for the university. The reader should obtain the same values if the methodology is followed and the computations are done correctly.

[3] An enrollee equals one student taking one subject. Alternative terms sometimes used are subject-students or student-subjects.

CLASSROOM REQUIREMENTS—MODEL W


FIRST YEAR DEPT I. ENROLLEES 1960
÷
CLASS SIZE 40
NUMBER OF FIRST YEAR SECTIONS IN DEPT I. 49
X
AVG. HOURS PER WEEK 2·0
CLASSROOM HOURS PER WEEK 98
INSERT ROOM REQUIREMENTS INTO A ROOM SIZE RANGE DETERMINED BY CLASS SIZE.
CLASS SIZE 75
AVG. HOURS PER WEEK 2·5
SECOND YEAR DEPT. I. ENROLLEES 1690
NUMBER OF SECOND YEAR SECTIONS IN DEPT. I.
CLASSROOM HOURS PER WEEK
GROSS CLASSROOM REQUIREMENTS IN ROOM-HOURS DEPT. I.
0-20 STUDENTS
98 20-60
60-100
100-180
180 UP
DEPT. I. TEACHING WEEK LENGTH (HOURS) 35
DEPT. I. ROOM UTILIZATION (PERCENT) 60
GROSS REQ NUMBE
0 0-
47 20
30 60
0 10
0 18
FIRST YEAR DEPT. 2 ENROLLEES 1000
DISTRIBUTION OF ENROLLEES INTO ROOM SIZE RANGES I'ST. YEAR DEPT. I. (PERCENT)
10 0-20 STUDENTS
30 20-60
20 60-100
35 100-180
5 180 UP
ENROLLEES TAKING CLASSES IN EACH ROOM SIZE RANGE
100 0-20 STUDENTS
300 20-60
200 60-100
350 100-180
50 180 UP
MID-POINTS OF ROOM SIZE RANGES
10 0-20 STUDENTS
40 20-60
80 60-100
140 100-180
250 180 UP
NUMBER OF SECTIONS REQUIRED
10·0 0-20 STUDENTS
7·5 20-60
2·5 60-100
2·5 100-180
·2 180 UP
AVG. HOURS PER WEEK 3·0
CLASSROOM HOURS PER WEEK
30·0 0-20 STUDENTS
22·5 20-60
7·5 60-100
7·5 100-180
·6 180 UP
Σ ALL YEARS
DISTRIBUTION OF ENROLLEES INTO ROOM SIZE RANGES 2'ND. YEAR DEPT. 2. (PERCENT)
10 0-20 STUDENTS
30 20-60
40 60-100
20 100-180
0 180 UP
SECOND YEAR DEPT. 2. ENROLLEES 2000
ENROLLEES TAKING CLASSES IN EACH ROOM SIZE RANGE
0-20 STUDENTS
20-60
60-100
100-180
180 UP
NUMBER OF SECTIONS REQUIRED
0-20 STUDENTS
20-60
60-100
100-180
180 UP
AVG. HOURS PER WEEK 2·0
CLASSROOM HOURS PER WEEK
0-20 STUDENTS
20-60
60-100
100-180
180 UP

IREMENTS–MODEL WORKSHEET


DEPT. I TEACHING WEEK LENGTH (HOURS)
35
÷
SROOM
NTS
OURS
STUDENTS
GROSS CLASSROOM REQUIREMENTS NUMBER OF ROOMS DEPT. I.
0 0–20 STUDENTS
4·7 20–60 "
3·0 60–100 "
0 100–180 "
0 180 UP "
÷
DEPT. I ROOM UTILIZATION (PERCENT)
60
Σ ALL DEPARTMENTS
UNIVERSITY CLASSROOM REQUIREMENTS NUMBER OF ROOMS
3·33 0–20 STUDENTS
7·20 20–60 "
4·31 60–100 "
·63 100–180 "
180 UP "
Σ ALL YEARS
GROSS CLASSROOM REQUIREMENTS IN ROOM–HOURS DEPT. 2
0–20 STUDENTS
20–60 "
60–100 "
100–180 "
180 UP "
DEPT. 2 TEACHING WEEK LENGTH (HOURS)
35
÷
÷
GROSS CLASSROOM REQUIREMENTS NUMBER OF ROOMS DEPT. 2
3·33 0–20 STUDENTS
2·50 20–60 "
1·31 60–100 "
·63 100–180 "
·03 180 UP "
DEPT. 2 ROOM UTILIZATION (PERCENT)
60

SECTION III EXPERIMENTS ON THE MODEL

The computer program contains several parameters which control the possible options and experiments. These parameters, their meanings, and their uses are explained in Table 1. The resource implications of various administrative decisions are simulated by the model and illustrated in the following pages. The initial conditions are shown in Figure 1 and the initial values assigned to main parameters are as follows:

BINT(INTRVL) =
0. to 20.
20. to 60.
60. to 100.
100. to 180.
180. and over

COSTIN = $20.00/sq. ft.

DRUTIL(IDPT)= 60.0%

IBEGIN = 66

IEND = 66

NINTI = 5

NPRIOR = 4

RUTIL = 60.0%

SKIP = 0.0

SSTOP = 0.0

SULOW = 60.0%

SULOWD = 100.0%

SUTAL = 100.0%

TEAWK(IDPT) = 35.0 hours

THIS = 10.0

UTEAWK = 35.0 hours

TABLE 1
MODEL PARAMETERS

NAME	DESCRIPTION	FUNCTION
AMTOFF(IDPT)	Percentage reduction of room requirements in the smallest size interval.	Used to reduce a department's requirements for small seminar and tutorial rooms, since a certain percentage of small classes are held in professors' offices.
ASSIGN(IDPT)	The number of additional rooms of the smallest size interval required.	Adds rooms of the smallest size range to a department's requirements if a room is needed for conferences or other special purposes.
AVGISS(IDPT,INTRVL)	The weighted average of the various class sizes that require room-hours in a particular size range.	The program searches for a room that is as close as possible in size to this number when fulfilling departmental requirements.
BINT(INTRVL)	The room size interval end points.	The number of seats in a room is compared to these end points to see in which size range the room belongs.
BLDPRI(IDPT,IPRIOR)	A departmental list of building priorities. Building numbers in the list correspond to those issued by the Physical Plant Department.	The program searches for suitable rooms in the first building on the list on the first iteration, then the second building on the next iteration, and so on.
COSTIN	Construction cost index $/sq. ft.	Applied to calculate the cost of additional lecture room facilities.
DIST(LABEL,INTRVL)	Departmental enrolment size range distribution.	Divides the forecasted enrollees for a given department and academic year into the various room size intervals.
DRUTIL(IDPT)	Departmental room utilization	Adjusts departmental room requirements by a factor (100.0/DRUTIL(IDPT)) to reflect the departmental scheduling efficiency.

HL(IDPT,IYR)	Forecasted hours/week/subject for each department and academic year.	Used in calculating the room-hours required by a department. HL depends on the subjects taught by a particular department in each year.
IBEGIN	The beginning simulation year.	Specifies the calendar year (e.g. 67) at which the program will start.
IEND	The final simulation year	Specifies the calendar year (e.g. 72) at which the simulation will stop.
NINT1	The number of size intervals.	If the number of room size intervals is varied, adjust NINT1. Maximum value is 7.
NPRIOR	Number of buildings listed for a department.	The program searches through the NPRIOR buildings when satisfying a department's room requirements.
ROLEES(IDPT,IYR)	The forecasted enrollees in each department and academic year.	This array must be adjusted if experiments are run analyzing a proposed departmental enrolment change.
RUTIL	University average room utilization.	The number of rooms required depends on RUTIL which is a function of the University scheduling efficiency. Vary RUTIL to investigate the effects of increased room utilization.
SKIP	Program control parameter.	If SKIP = 0.0, the complete program is executed. If SKIP = 1.0, subroutine MATCH is not executed and the departmental matching reports are not printed.
SSTOP	Program control parameter.	If SSTOP = 0.0, the matching optimization routine is suppressed and the user must supply a value of SUTAL. If SSTOP = 1.0, the optimization routine starts at SUTAL and searches for the best match, decreasing SUTAL by THIS on each iteration.

STR(IDPT,IYR)	The forecasted class sizes in each academic year of every department.	This array must be adjusted to investigate the resource implications of proposed class size changes.
SULOW	Lowest tolerable value of seat utilization when matching departmental room requirements against available space.	The optimization routine ceases matching if SUTIL is less than or equal to SULOW. The program transfers to the printing of departmental matching reports.
SULOWD	Seat utilization parameter for the University-wide matching process.	SULOWD is used to adjust the room size interval end points.
SUTAL	Starting seat utilization in the matching process.	The program starts at SUTAL and successively decreases this by THIS when matching (if SSTOP = 1.0).
SUTIL	Seat utilization parameter used in the matching process when SSTOP = 1.0	Set equal to the previous value of seat utilization minus the decrement THIS. Used to adjust the size interval end points.
TEAWK(IDPT)	Departmental teaching week length (hours).	The forecasted room-hours requirements of a department are divided by the teaching week length to obtain room requirements/week.
THIS	Seat utilization decrement.	If SSTOP = 1.0, the starting seat utilization is decreased by an amount THIS on each matching iteration leading to the optimum match.
UTEAWK	University-wide average teaching week length (hours).	The forecasted space requirements in room-hours are divided by UTEAWK to calculate the number of rooms required.

Example 1 Format of Basic University-Wide Report

Figure 1 is a university-wide report comparing forecasted lecture room space requirements in each size interval (summed over all departments) with the space available at the university. There are three sections to the report. At the top of the page the total number of rooms available is matched against the total number of rooms required and a differential is calculated. A negative differential indicates a shortage of rooms of that size; a positive differential indicates an excess. A shortage of 31.3 tutorial rooms is indicated in Figure 1. However, small classes may be taught in large rooms (but not vice-versa); therefore, in practice we may satisfy this shortage of 31.3 rooms by allocating tutorial classes to rooms in the higher size ranges. Naturally the seat utilization in these larger rooms will be quite low. The exigencies of the current situation may demand this. Further, such a redistribution of space may be more desirable than incurring the costs of constructing more rooms of size 0. to 20. The centre section of Figure 1 evaluates and reports the realities of space deficiencies if small classes are to be taught in larger rooms. The lowest section compares forecasted space requirements calculated as room-hours versus room-hours available by size interval. The utilization of room-hours is calculated and compared to the utilization that can be attained with the present scheduling efficiency of the university.

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                     UNIVERSITY WIDE MATCHING REPORT FOR LECTURE ROOM FACILITIES
                     ===========================================================
                                         TERM  1966-67

                                LECTURE, SEMINAR, AND TUTORIAL ROOMS
                                ------------------------------------

   SIZE(STUDENTS)   *    TOTAL ROOMS AVAILABLE    *    FORECASTED TOTAL ROOMS REQUIRED    *    DIFFERENTIAL
 -------------------*-----------------------------*---------------------------------------*----------------
    0. TO    20.    *             53.0            *                  84.3                  *       -31.3
   20. TO    60.    *             78.0            *                  72.6                  *         5.4
   60. TO   100.    *             46.0            *                  20.4                  *        25.6
  100. TO   180.    *             30.0            *                  11.7                  *        18.3
  180. TO   999.    *             20.0            *                   3.9                  *        16.1
 -------------------*-----------------------------*---------------------------------------*----------------

NUMBER OF ROOMS CALCULATED USING A TEACHING WEEK OF  35.0 HOURS
ROOM UTILIZATION PARAMETER SET AT  60.0 PERCENT
SEAT UTILIZATION PARAMETER SET AT 100.0 PERCENT


SINCE SEMINARS, TUTORIALS, AND LECTURES MAY BE HELD IN A LARGER ROOM (WITH A CORRESPONDING DROP IN SEAT UTILIZATION),
 THE ACTUAL OVERAGES OR UNDERAGES BY SIZE RANGE ARE AS FOLLOWS-

   SIZE(STUDENTS)     ACTUAL OVERAGES OR UNDERAGES
   --------------     ----------------------------
    0. TO    20.                 0.0
   20. TO    60.                 0.0
   60. TO   100.                 0.0
  100. TO   180.                18.0
  180. TO   999.                16.1

                                         TOTAL ROOM-HOURS
                                         ----------------

 SIZE(STUDENTS) * REQUIRED * AVAILABLE * DIFFERENTIAL * UTILIZATION * DEV. FROM EXPECTED UTILIZ. * EXPECTED OVERAGE OR UNDERAGE
 ---------------*----------*-----------*--------------*-------------*----------------------------*-----------------------------
   0. TO    20. *   2213.2 *   1855.0  *    -358.2    *     119.3   *            59.3            *          -1833.6
  20. TO    60. *   1524.2 *   2730.0  *    1205.8    *      55.8   *            -4.2            *            189.6
  60. TO   100. *    429.2 *   1610.0  *    1180.8    *      26.7   *           -33.3            *            894.6
 100. TO   180. *    245.9 *   1050.0  *     804.1    *      23.4   *           -36.6            *            540.2
 180. TO   999. *     82.9 *    700.0  *     617.1    *      11.8   *           -48.2            *            561.9
 ---------------*----------*-----------*--------------*-------------*----------------------------*-----------------------------

EXPECTED UTILIZATION OF  60.0 PERCENT IS BASED ON THE SCHEDULING SOPHISTICATION OF THE UNIVERSITY
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FIGURE 1

For example, suppose 1000 room-hours are available in a certain interval and 720 room-hours are required. Then,

$$\text{Required Percent Utilization} = \frac{720}{1000} \times 100\% = 72\%$$

Further, suppose the actual percent utilization possible through the existing loading and scheduling system is 60%, then, the available room-hours must be adjusted by an index which reflects the utilization differential, namely

$$\frac{72\%}{60\%} = 1.2$$

And, the actual number of room-hours required to satisfy demand is

1000 x 1.2 = 1200 room-hours

The shortage of room-hours is

1200 - 1000 = 200 room-hours

This shortage is reported in the "Expected Overage or Underage" column of the "Room-Hours" section of the report.

Example 2 Increase in Length of Teaching Week

Suppose we desire to investigate the effect on lecture room requirements of a forty-hour teaching week rather than the present thirty-five hours (9 to 1 and 2 to 5 o'clock, 5 days a week.)

Set UTEAWK = 40.0 and set the array TEAWK(IDPT)= 40.0
(Assume all departments have the same teaching week length).

The output shown in Figure 2 indicates a drop in the forecasted rooms required over all size intervals resulting from the longer teaching week. The number of room-hours required remains the same but the availability of room-hours increases thereby helping to reduce a shortage such as exists in the size range of 0. to 20. This reduction in the forecasted total rooms required would reduce the magnitude and cost of the lecture room building program. When evaluating the proposal, this saving in construction costs could be compared against any additional costs such as higher remuneration for teaching staff, higher maintenance costs, et cetera.

Graph 1 shows the relationship of room requirements to the university teaching week length for each lecture room size interval. The reduction in room requirements through a longer teaching week can be read directly off the graph.

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                                            TERM  1966-67

                                 LECTURE, SEMINAR, AND TUTORIAL ROOMS
                                 ------------------------------------

     SIZE(STUDENTS)    *    TOTAL ROOMS AVAILABLE    *    FORECASTED TOTAL ROOMS REQUIRED    *    DIFFERENTIAL
   -------------------*-----------------------------*---------------------------------------*----------------
      0. TO   20.     *            53.0             *                 73.8                  *      -20.8
     20. TO   60.     *            78.0             *                 63.5                  *       14.5
     60. TO  100.     *            46.0             *                 17.9                  *       28.1
    100. TO  180.     *            30.0             *                 10.2                  *       19.8
    180. TO  999.     *            20.0             *                  3.5                  *       16.5
   -------------------*-----------------------------*---------------------------------------*----------------

  NUMBER OF ROOMS CALCULATED USING A TEACHING WEEK OF  40.0 HOURS
  ROOM UTILIZATION PARAMETER SET AT  60.0 PERCENT
  SEAT UTILIZATION PARAMETER SET AT 100.0 PERCENT

  SINCE SEMINARS, TUTORIALS, AND LECTURES MAY BE HELD IN A LARGER ROOM (WITH A CORRESPONDING DROP IN SEAT UTILIZATION),
   THE ACTUAL OVERAGES OR UNDERAGES BY SIZE RANGE ARE AS FOLLOWS-

     SIZE(STUDENTS)     ACTUAL OVERAGES OR UNDERAGES
     --------------     ----------------------------
      0. TO   20.                   0.0
     20. TO   60.                   0.0
     60. TO  100.                  21.8
    100. TO  180.                  19.8
    180. TO  999.                  16.5

                                         TOTAL ROOM-HOURS
                                         ----------------

   SIZE(STUDENTS) * REQUIRED * AVAILABLE * DIFFERENTIAL * UTILIZATION * DEV. FROM EXPECTED UTILIZ. * EXPECTED OVERAGE OR UNDERAGE
   ---------------*----------*-----------*--------------*-------------*----------------------------*------------------------------
     0. TO   20. *   2213.2 *   2120.0  *     -93.2    *    104.4    *            44.4            *           -1568.6
    20. TO   60. *   1524.2 *   3120.0  *    1595.8    *     48.9    *           -11.1            *             579.6
    60. TO  100. *    429.2 *   1840.0  *    1410.8    *     23.3    *           -36.7            *            1124.6
   100. TO  180. *    245.9 *   1200.0  *     954.1    *     20.5    *           -39.5            *             790.2
   180. TO  999. *     82.9 *    800.0  *     717.1    *     10.4    *           -49.6            *             661.9
   ---------------*----------*-----------*--------------*-------------*----------------------------*------------------------------

  EXPECTED UTILIZATION OF  60.0 PERCENT IS BASED ON THE SCHEDULING SOPHISTICATION OF THE UNIVERSITY
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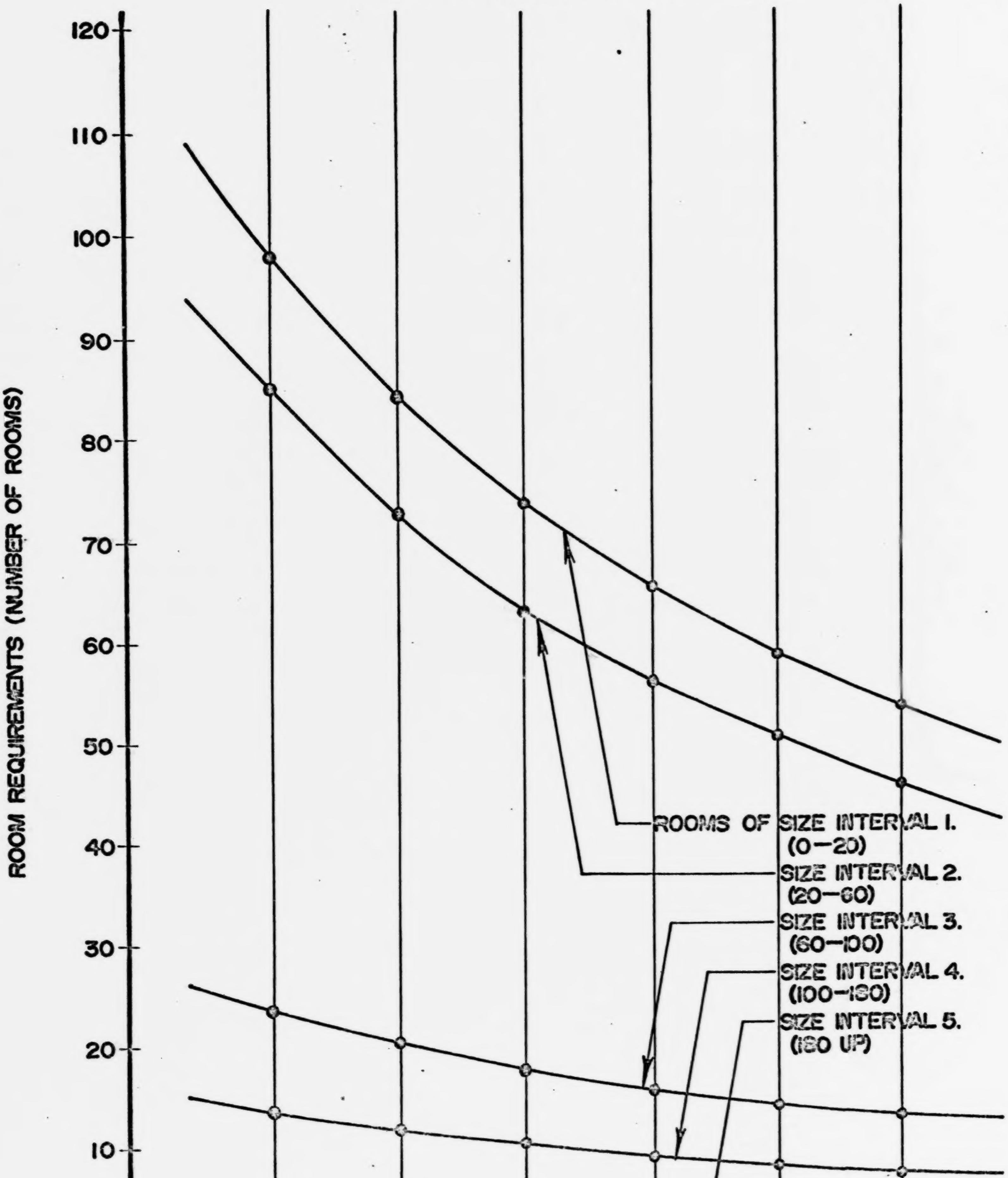
FIGURE 2

Graph I.

VARIATION OF FORECASTED ROOM REQUIREMENTS WITH THE UNIVERSITY TEACHING WEEK



Example 3 Increase in Room Utilization

Consider now a proposal for a more sophisticated (perhaps computerized) lecture-room scheduling system. Increased scheduling efficiency will improve the utilization of existing rooms and reduce the requirements for rooms. If the new scheduling system is expected to increase room utilization by, say 10%, we change the model room utilization parameters to 70% from the present room utilization of 60%.

Set RUTIL = 70.0 and

the array DRUTIL(IDPT) = 70.0 (Assume all departments have the same room utilization).

Figure 3 illustrates the drop in the forecasted total rooms required and an improved position in the expected overage or shortage of room-hours. The influence of different values of room utilization on room requirements has been simulated and the results are plotted on Graph 2.

Suppose we wish to examine the long term effects of increased room utilization. The program produces the report shown in Figure 4. This report is a summary of the university room requirements over several years. In addition, a rough indicator of the cost involved in building lecture room facilities is reported. The numbers in Figure 4 are representative only since detailed enrolment forecasts for the next several years are not available yet (a 2% increase in the number of enrollees in each

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                          LECTURE, SEMINAR, AND TUTORIAL ROOMS
                          ------------------------------------

   SIZE(STUDENTS)   *    TOTAL ROOMS AVAILABLE    *   FORECASTED TOTAL ROOMS REQUIRED   *   DIFFERENTIAL
   ----------------*----------------------------*------------------------------------*---------------
     0. TO   20.    *            53.0             *               72.3                  *      -19.3
    20. TO   60.    *            78.0             *               62.2                  *       15.8
    60. TO  100.    *            46.0             *               17.5                  *       28.5
   100. TO  180.    *            30.0             *               10.0                  *       20.0
   180. TO  999.    *            20.0             *                3.4                  *       16.6
   ----------------*----------------------------*------------------------------------*---------------

NUMBER OF ROOMS CALCULATED USING A TEACHING WEEK OF  35.0 HOURS
ROOM UTILIZATION PARAMETER SET AT  70.0 PERCENT
SEAT UTILIZATION PARAMETER SET AT 100.0 PERCENT

SINCE SEMINARS, TUTORIALS, AND LECTURES MAY BE HELD IN A LARGER ROOM (WITH A CORRESPONDING DROP IN SEAT UTILIZATION),
 THE ACTUAL OVERAGES OR UNDERAGES BY SIZE RANGE ARE AS FOLLOWS-

   SIZE(STUDENTS)     ACTUAL OVERAGES OR UNDERAGES
   --------------     ----------------------------
     0. TO   20.                 0.0
    20. TO   60.                 0.0
    60. TO  100.                25.0
   100. TO  100.                20.0
   180. TO  999.                16.6

                                      TOTAL ROOM-HOURS
                                      ----------------

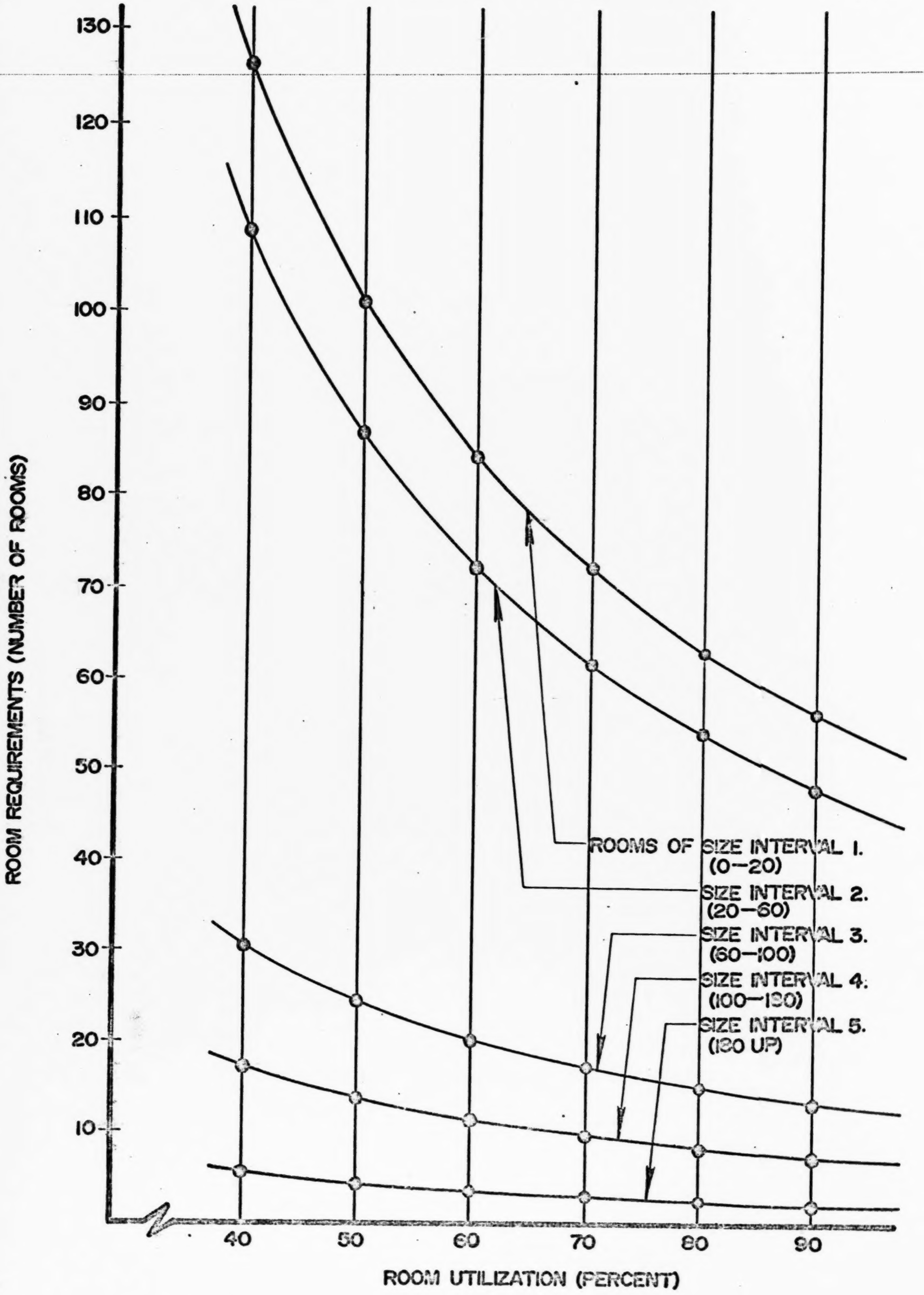
 SIZE(STUDENTS) * REQUIRED * AVAILABLE * DIFFERENTIAL * UTILIZATION * DEV. FROM EXPECTED UTILIZ. * EXPECTED OVERAGE OR UNDERAGE
 --------------*----------*-----------*--------------*-------------*----------------------------*------------------------------
   0. TO   20. *  2213.2 *   1855.0  *    -358.2    *    119.3    *            49.3            *          -1306.7
  20. TO   60. *  1524.2 *   2730.0  *    1205.8    *     55.8    *           -14.2            *            552.5
  60. TO  100. *   429.2 *   1610.0  *    1180.8    *     26.7    *           -43.3            *            996.8
 100. TO  180. *   245.9 *   1050.0  *     804.1    *     23.4    *           -46.6            *            698.8
 180. TO  999. *    82.9 *    700.0  *     617.1    *     11.8    *           -58.2            *            581.6
 --------------*----------*-----------*--------------*-------------*----------------------------*------------------------------

EXPECTED UTILIZATION OF  70.0 PERCENT IS BASED ON THE SCHEDULING SOPHISTICATION OF THE UNIVERSITY
```

FIGURE 3

VARIATION OF FORECASTED ROOM REQUIREMENTS WITH THE UNIVERSITY ROOM UTILIZATION

Graph 2.



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                  ============================================================

               SUMMARY OF ACTUAL EXCESS OR SHORTAGE OF ROOMS FOR 10 SIMULATION YEARS
               ---------------------------------------------------------------------

SIZE(STUDENTS)   1966-67   1967-68   1968-69   1969-70   1970-71   1971-72   1972-73   1973-74   1974-75   1975-76

  0. TO   20.      0.0       0.0       0.0      -2.8     -25.7     -56.1     -88.0    -110.5    -140.0    -178.6
 20. TO   60.      0.0       0.0       0.0       0.0       0.0       0.0      -7.7     -36.8     -74.7    -121.4
 60. TO  100.      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0      -3.1
100. TO  180.     18.0       7.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
180. TO  999.     16.1      15.9      14.3       0.0       0.0       0.0       0.0       0.0       0.0       0.0
CHANGING PATTERN OF ROOM SHORTAGES INDICATES WHEN ROOMS SHOULD BE BUILT, AND THE NUMBER AND SIZES OF ROOMS

                   ESTIMATED CONSTRUCTION COST FOR LECTURE ROOM FACILITIES
                   -------------------------------------------------------
                          CONSTRUCTION COST INDEX = $ 20.00/SQ. FT.

                SIZE(STUDENTS)     ROOM REQUIREMENTS     SQUARE FOOTAGE        COST

                  0. TO   20.           -178.6              -45839.0     $  916779.41
                 20. TO   60.           -121.4              -69314.7     $ 1386293.86
                 60. TO  100.             -3.1               -3149.2     $   62983.28
                100. TO  180.              0.0                   0.0     $       0.00
                180. TO  999.              0.0                   0.0     $       0.00
                                                                         -------------
                                                                         $ 2366056.50
```

FIGURE 4

department was assumed each simulation year), and the room inventory was constant (no rooms constructed). Figure 4 illustrates a control report with the University teaching week length equal to 35.0 hours and room utilization equal to 60.0%.

The long-run effects of increasing room utilization to 70% can be seen in Figure 5. There is not only a reduction in the number of rooms required but the University will not have a shortage of rooms until 2 years later. (Compare 1969-70 in Figure 4 to 1971-72 in Figure 5). The estimated construction cost saving is 29% (684,000 dollars) which, even as a rough estimate, demonstrates the return on a relatively small percentage increase in scheduling efficiency.

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                 ===========================================================

            SUMMARY OF ACTUAL EXCESS OR SHORTAGE OF ROOMS FOR 10 SIMULATION YEARS
            ---------------------------------------------------------------------

SIZE(STUDENTS)   1966-67   1967-68   1968-69   1969-70   1970-71   1971-72   1972-73   1973-74   1974-75   1975-76

  0. TO   20.      0.0       0.0       0.0       0.0       0.0     -15.6     -49.6     -87.2    -112.4    -145.5
 20. TO   60.      0.0       0.0       0.0       0.0       0.0       0.0       0.0      -6.7     -39.2     -81.9
 60. TO  100.     25.0      18.9       9.4       0.0       0.0       0.0       0.0       0.0       0.0       0.0
100. TO  180.     20.0      16.6      18.9      14.1       0.0       0.0       0.0       0.0       0.0       0.0
180. TO  999.     16.6      16.5      16.3      16.0      10.4       0.0       0.0       0.0       0.0       0.0
CHANGING PATTERN OF ROOM SHORTAGES INDICATES WHEN ROOMS SHOULD BE BUILT, AND THE NUMBER AND SIZES OF ROOMS

                 ESTIMATED CONSTRUCTION COST FOR LECTURE ROOM FACILITIES
                 -------------------------------------------------------
                       CONSTRUCTION COST INDEX = $ 20.00/SQ. FT.

            SIZE(STUDENTS)     ROOM REQUIREMENTS     SQUARE FOOTAGE        COST

              0. TO   20.           -145.5             -37347.0       $  746939.46
             20. TO   60.            -81.9             -46751.1       $  935022.35
             60. TO  100.              0.0                  0.0       $       0.00
            100. TO  180.              0.0                  0.0       $       0.00
            180. TO  999.              0.0                  0.0       $       0.00
                                                                      -------------
                                                                      $ 1681961.81
```

FIGURE 5

Example 4 Increase in Length of Teaching Week and an Associated Improvement in Room Utilization

Several parameters may be varied simultaneously to investigate the effects and inter-relationship of several space management decisions. For example, suppose an expected increase of 10% in room utilization is combined with a longer teaching week of 40 hours.

Set UTEAWK = 40.0

Set RUTIL = 70.0

Set the array TEAWK(IDPT) = 40.0

Set the array DRUTIL(IDPT) = 70.0

The combined results are shown in Figure 6. The forecasted total rooms required are lower than in Figures 2 or 3. A 10-year simulation could be run and would show a much improved position over Figure 4.

As a further indication of the information generated by the model, consider the departmental report shown in Figure 7. This is a typical departmental report which details the number of hours required in lecture rooms of each size and the number of rooms required per week. If a department requires more than one room of any size, the programme searches through the department's home building and neighbouring buildings for rooms of the correct size and type. This searching is performed on the premise that professors and students of that department would prefer lecture rooms in the appropriate size range available near the department's offices rather than to have to move back and forth across the campus. Figure 7 shows the three rooms

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                                        TERM  1966-67

                               LECTURE, SEMINAR, AND TUTORIAL ROOMS
                               ------------------------------------

      SIZE(STUDENTS)    *    TOTAL ROOMS AVAILABLE     *    FORECASTED TOTAL ROOMS REQUIRED    *    DIFFERENTIAL
      ------------------*------------------------------*---------------------------------------*----------------
         0. TO    20.   *            53.0              *                63.2                   *       -10.2
        20. TO    60.   *            78.0              *                54.4                   *        23.6
        60. TO   100.   *            46.0              *                15.3                   *        30.7
       100. TO   180.   *            30.0              *                 8.8                   *        21.2
       180. TO   999.   *            20.0              *                 3.0                   *        17.0
      ------------------*------------------------------*---------------------------------------*----------------


    NUMBER OF ROOMS CALCULATED USING A TEACHING WEEK OF  40.0 HOURS
    ROOM UTILIZATION PARAMETER SET AT  70.0 PERCENT
    SEAT UTILIZATION PARAMETER SET AT 100.0 PERCENT

    SINCE SEMINARS, TUTORIALS, AND LECTURES MAY BE HELD IN A LARGER ROOM (WITH A CORRESPONDING DROP IN SEAT UTILIZATION),
     THE ACTUAL OVERAGES OR UNDERAGES BY SIZE RANGE ARE AS FOLLOWS-

      SIZE(STUDENTS)     ACTUAL OVERAGES OR UNDERAGES
      --------------     ----------------------------
         0. TO    20.                0.0
        20. TO    60.               13.3
        60. TO   100.               30.7
       100. TO   180.               21.2
       180. TO   999.               17.0

                                        TOTAL ROOM-HOURS
                                        ----------------

    SIZE(STUDENTS) * REQUIRED * AVAILABLE * DIFFERENTIAL * UTILIZATION * DEV. FROM EXPECTED UTILIZ. * EXPECTED OVERAGE OR UNDERAGE
    ---------------*----------*-----------*--------------*-------------*----------------------------*-----------------------------
       0. TO    20. *  2213.2 *  2120.0   *     -93.2    *    104.4    *            34.4            *           -1041.7
      20. TO    60. *  1524.2 *  3120.0   *    1595.8    *     48.9    *           -21.1            *             942.5
      60. TO   100. *   429.2 *  1840.0   *    1410.8    *     23.3    *           -46.7            *            1226.8
     100. TO   180. *   245.9 *  1200.0   *     954.1    *     20.5    *           -49.5            *             840.8
     180. TO   999. *    82.9 *   800.0   *     717.1    *     10.4    *           -59.6            *             681.6
    ---------------*----------*-----------*--------------*-------------*----------------------------*-----------------------------

    EXPECTED UTILIZATION OF  70.0 PERCENT IS BASED ON THE SCHEDULING SOPHISTICATION OF THE UNIVERSITY
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FIGURE 6

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                                                                                REPORT PAGE 1
                                 UNIVERSITY  OF  TORONTO
                         C.A.M.P.U.S.  SIMJLATION  PLANNING  ANALYSIS

                                   ZOOLOGY          REPORT
                             --------------------------------

                               FORECASTED SPACE REQJIREMENTS

                    LECTURE ROOM DISTRIBUTION IN ROOM-HOURS BY ROOM SIZE RANGE

         SIZE(STUDENTS)          ROOM-HOURS REQD.          NO. OF ROOMS       UNSATISFIED ROOM REQ. AFTER MATCHING

            0. TO   20.               37.0                     1.41                        0.41
           20. TO   60.               41.4                     1.97                        0.97
           60. TO  100.               27.6                     1.31                        0.31
          100. TO  180.                2.9                     0.14                        0.14
          180. TO  999.                2.8                     0.13                        0.13

  NUMBER OF ROOMS CALCULATED USING A TEACHING WEEK OF  35.0 HOURS
  ROOM UTILIZATION PARAMETER SET AT  60.0 PERCENT
  SEAT UTILIZATION PARAMETER SET AT 100.0 PERCENT

     THE FOLLOWING ROOMS ARE AVAILABLE TO SATISFY THE ROOM REQUIREMENTS FOR        ZOOLOGY

                 BUILDING NAME   ROOM NUMBER   ROOM CAPACITY   SEAT UTILIZATION
                 -------------   -----------   -------------   ----------------

               RAMSAY WRIGHT BLDG     141           20.             54.0

               RAMSAY WRIGHT BLDG     142           40.             95.5

               SIDNEY SMITH HALL     1087           98.             82.2
```

FIGURE 7

(one of each size range) that were tagged as suitable for Zoology's requirements. These rooms may be used by Central Room Allocation when scheduling lecture space for Zoology since these rooms correspond in size to the average class sizes in Zoology. If rooms of appropriate size are found for a department, they are subtracted from the number of rooms required to give the unsatisfied room requirements after matching. The seat utilization specified for the rooms located is computed by dividing the average class size of a department in a size interval by the size of room. The room with a computed seat utilization of closest to 100% is chosen.

The effect of a departmental room utilization increase of 10% and a longer teaching week of 40.0 hours is shown in Figure 8. Note that the Zoology department no longer requires a room in the third size range. The unsatisfied room requirements (fractional requirements) are scheduled from any rooms remaining in the central room pool. The search for the correct size of room near a department's offices is done only for whole numbers of rooms.

The departmental information shown on Figures 7 and 8 is summed to produce part of the information shown on the university-wide matching report. However, space requirements are summed at the Faculty level also, and a typical Faculty report (35.0 hour teaching week and 60.0% room utilization) is shown in Figure 9.

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                        C.A.M.P.U.S.  SIMULATION  PLANNING  ANALYSIS

                                      ZOOLOGY           REPORT
                                 --------------------------------

                                   FORECASTED SPACE REQUIREMENTS

                      LECTURE ROOM DISTRIBUTION IN ROOM-HOURS BY ROOM SIZE RANGE

      SIZE(STUDENTS)          ROOM-HOURS REQD.        NO. OF ROOMS      UNSATISFIED ROOM REQ. AFTER MATCHING

        0. TO   20.                37.0                   1.06                      0.06
       20. TO   60.                41.4                   1.48                      0.48
       60. TO  100.                27.6                   0.98                      0.98
      100. TO  180.                 2.9                   0.10                      0.10
      180. TO  999.                 2.8                   0.10                      0.10

NUMBER OF ROOMS CALCULATED USING A TEACHING WEEK OF  40.0 HOURS
ROOM UTILIZATION PARAMETER SET AT  70.0 PERCENT
SEAT UTILIZATION PARAMETER SET AT 100.0 PERCENT

    THE FOLLOWING ROOMS ARE AVAILABLE TO SATISFY THE ROOM REQUIREMENTS FOR       ZOOLOGY

                   BUILDING NAME   ROOM NUMBER   ROOM CAPACITY   SEAT UTILIZATION
                   -------------   -----------   -------------   ----------------

                 RAMSAY WRIGHT BLDG     141           20.             54.0

                 RAMSAY WRIGHT BLDG     142           40.             95.5
```

FIGURE 8

```
                         UNIVERSITY   OF   TJRONTO

             C.A.M.P.U.S.  SIMULATION  PLANNING  ANALYSIS

                    SUMMARY FOR APPLIED SCIENCE AND ENG.

                       FORECASTED SPACE REQJIREMENTS
                       -----------------------------

         LECTURE ROOM DISTRIBUTION IN ROOM-HOURS BY ROOM SIZE RANGE

          SIZE(STUDENTS)          ROOM-HOURS REQD.          NO. OF ROOMS

            0. TO   20.                193.4                     7.4
           20. TO   60.                229.1                    10.9
           60. TO  100.                 54.9                     2.6
          100. TO  180.                  3.5                     0.2
          180. TO  999.                  0.0                     0.0
```

FIGURE 9

Example 5 Varying Seat Utilization Parameters

The program endeavours to find lecture rooms to match or satisfy whole number room requirements for each department in each size range. For example, the Zoology department requires a room capacity of 60 to 100 students (see Figure 7), so the program confines its search to rooms only of that size range. A suitable room was found in a neighbouring building - Sydney Smith Hall.

Suppose we wish to investigate whether a slightly larger room than 100 seats is available in a department's home building. The size interval upper end points are adjusted by SUTAL which has an initial value of 100.0% in Figure 7. Expansion of the size interval reduces the seat utilization we would expect for classes occupying the room because a larger size room is used to fulfill a room requirement normally satisfied by the size range of 60 to 100 seats. An example will illustrate this point. If the seat utilization parameter SUTAL = 65%, the program searches for a room of capacity 60 to 153 students (100 times 100/65 = 153). Figure 10 shows the result. A room with a capacity of 150 was found in Zoology's home building. Of course, the average seat utilization that may be expected is quite low (i.e. 53.7%) because we would normally allocate this room to class sizes in the 60 to 100 range.

In general, relaxing the tolerance on seat utilization below the desired level of 100% (i.e., expanding the room size

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                              ZOOLOGY           REPORT
                         ---------------------------------

                            FORECASTED SPACE REQUIREMENTS

                 LECTURE ROOM DISTRIBUTION IN ROOM-HOURS BY ROOM SIZE RANGE
      SIZE(STUDENTS)          ROOM-HOURS REQD.         NO. OF ROOMS       UNSATISFIED ROOM REQ. AFTER MATCHING

        0.  TO   20.               37.0                  1.41                         0.41
       20.  TO   60.               41.4                  1.97                         0.97
       60.  TO  100.               27.6                  1.31                         0.31
      100.  TO  180.                2.9                  0.14                         0.14
      180.  TO  999.                2.8                  0.13                         0.13

  NUMBER OF ROOMS CALCULATED USING A TEACHING WEEK OF  35.0 HOURS
  ROOM UTILIZATION PARAMETER SET AT  60.0 PERCENT
  SEAT UTILIZATION PARAMETER SET AT  65.0 PERCENT

     THE FOLLOWING ROOMS ARE AVAILABLE TO SATISFY THE ROOM REQUIREMENTS FOR        ZOOLOGY

                 BUILDING NAME    ROOM NUMBER   ROOM CAPACITY   SEAT UTILIZATION
                 -------------    -----------   -------------   ----------------

               RAMSAY WRIGHT BLDG     141           20.              54.0

               RAMSAY WRIGHT BLDG     142           40.              95.5

               RAMSAY WRIGHT BLDG     117          150.              53.7
```

FIGURE 10

intervals) will cause the computed seat utilizations for matched rooms to be lower. However, by using the slightly expanded size intervals the program will be able to achieve a better matching of room requirements against available facilities. Departments that could not find a room in a particular size range might find a slightly larger room close to its academic offices. If this is so the percentage of rooms matched versus the number of rooms to be matched will be greater.

Figure 11 (SUTAL = 100%) is an output of the average seat utilization and matching efficiency for rooms of each size interval. Note that the average seat utilization may be larger than 100% as it is in the room size interval 180 to 999. The seat utilization concept of this computer model differs slightly from the usual connotation of seat utilization which is the number of seats occupied as a percentage of available seats. For our purposes the analysis proceeds in this way. A particular department could have several different class sizes requiring room-hours in a room of size 180 - 999. To account for this we compute a weighted average of the class sizes in each room size interval for each department. Suppose, for example, the weighted average of the class sizes for a department is 250. The capacities of rooms available to a department in the size interval 180 - 999 are compared to this number and values of seat utilization (250/capacity x 100%) are computed to obtain a relative measure of the goodness of fit of each room to the class sizes to be taught by that department in that room size interval. The room with a value of seat utilization closest to 100 percent (though perhaps > 100%) is chosen. It may be that some classes will not fit in the room; this problem is resolved

```
AVERAGE SEAT UTILIZATION FOR ROOMS ASSIGNED TO INDIVIDUAL DEPARTMENTS

                SIZE(STUDENTS)          SEAT UTILIZATION

                  0. TO   20.                58.1
                 20. TO   60.                99.7
                 60. TO  100.                96.8
                100. TO  180.                90.6
                180. TO  999.               130.3

                 OVERALL SEAT UTILIZATION =  95.1 PERCENT



MATCHING EFFICIENCY BY SIZE INTERVAL = NUMBER OF ROOMS MATCHED/NUMBER OF ROOMS TO BE MATCHED TIMES 100 PERCENT

                SIZE(STUDENTS)          MATCHING EFFICIENCY

                  0. TO   20.               71.9 PERCENT
                 20. TO   60.               83.0 PERCENT
                 60. TO  100.              100.0 PERCENT
                100. TO  180.               83.3 PERCENT
                180. TO  999.              100.0 PERCENT

               OVERALL MATCHING EFFICIENCY =  87.6 PERCENT
```

FIGURE 11

(SUTAL = 100%)

in the real system by scheduling the larger classes in a larger room. This particular program is limited to determining if any room in a size interval is available near a department's offices to fulfill a room requirement in that size interval. The computed value of seat utilization is a further aid in deciding which room, of perhaps several in the interval, corresponds most closely to the class sizes taught by that department.

We may wish to know if an improved matching of room requirements and lecture room facilities at the departmental level is possible by expanding the size intervals slightly. For instance, if the model is run with SUTAL = 65.0, the situation changes to that shown in Figure 12. The building search routine has found suitable rooms for all departments requiring rooms in the first three size intervals, and high matching efficiency in the remaining two size intervals. However, the overall seat utilization for matched rooms has dropped to a lower level. Experiments with many different values of SUTAL may be run to find a desired combination of matching efficiency and overall seat utilization.

The objective of the departmental matching process is to provide a quantitative assessment of the extent to which classrooms of the proper size are available to meet the mix of class sizes conducted by the academic departments. Rooms are tagged as suitable for scheduling a particular department's lectures. The computer program tabulates these tagged rooms and also the rooms which may be too small or much larger than the requirements of

```
        AVERAGE SEAT UTILIZATION FOR ROOMS ASSIGNED TO INDIVIDUAL DEPARTMENTS

                 SIZE(STUDENTS)         SEAT UTILIZATION

                   0. TO   20.              58.9
                  20. TO   60.              58.0
                  60. TO  100.              71.4
                 100. TO  180.              63.9
                 180. TO  999.              76.7

                  OVERALL SEAT UTILIZATION =  57.8 PERCENT



MATCHING EFFICIENCY BY SIZE INTERVAL = NUMBER OF ROOMS MATCHED/NUMBER OF ROOMS TO BE MATCHED TIMES 100 PERCENT

                 SIZE(STUDENTS)         MATCHING EFFICIENCY

                   0. TO   20.             81.3 PERCENT
                  20. TO   60.             75.6 PERCENT
                  60. TO  100.            100.0 PERCENT
                 100. TO  180.            100.0 PERCENT
                 180. TO  999.            100.0 PERCENT

               OVERALL MATCHING EFFICIENCY =  91.6 PERCENT
```

FIGURE 12

(SUTAL = 65%)

the departments in that building. The percentage of rooms tagged or matched in each building is reported as shown in Figure 13. These percentages indicate the utilization of lecture-room space in a building. A high percentage means the rooms are suitable for the class size mix of the departments housed in the building; a high seat utilization would result if the departmental room requirements are fulfilled by these rooms. This report could also be used in conjunction with the departmental matching report and reports of other types of space to assist planners in relocating a department in another building on campus.

```
PERCENTAGE OF ROOMS MATCHED IN EACH BUILDING

 BUILDING NAME          PERCENTAGE MATCHED
ANATOMY BUILDING                0.0
ARCHITECTURE BLDG              75.0
BANTING INSTITUTE               0.0
BEST INSTITUTE                  0.0
BOTANY BUILDING                 0.0
SCHOOL OF BUSINESS             33.3
CONSERV. OF MUSIC             100.0
EDWARD JOHNSON                 58.3
ELECTRICAL BLDG                 0.0
EXTENSION DIVISION              0.0
FOOD SCIENCES                   0.0
FORESTRY BUILDING              66.7
GALBRAITH BUILDING             40.0
HYGIENE BUILDING               33.3
LASH MILLER BLDG               85.7
LIBRARY SCIENCE B              66.7
LIBRARY SCIENCE A              25.0
MECHANICAL BLDG                 0.0
MEDICAL BUILDING                0.0
MINING BUILDING                33.3
NEW COLLEGE                   100.0
NEW PHYSICS BLDG               36.4
SCHOOL OF NURSING              50.0
OLD PHSICS BLDG                25.0
PHARMACY BUILDING              65.7
RAMSAY WRIGHT BLDG            100.0
ROYAL ONT  MUSEUM               0.0
SIDNEY SMITH HALL              71.7
SUSSEX COURT                  100.0
UNIVERSITY COLLEGE             43.8
WALLBERG BUILDING              37.5
```

FIGURE 13

Example 6 Physical Facilities Reports - Lecture Rooms.

The computer program compares the forecasted requirements for lecture rooms with the lecture rooms available for each year simulated. One of the program subroutines updates the list of lecture rooms for each session by:

(1) deleting rooms which are being razed in that session

(2) temporarily removing any rooms being renovated

(3) adding rooms scheduled for construction in that session.

A complete list of the rooms available for an academic session is printed in the format of Figure 14. This report contains the following information:

Building name and number

Room number

Number of seats in the room

The affiliation of the room to a faculty and/or department

Number of hours of restricted usage

Square footage of the room

Number of square feet/seat in a room

Deviation from the average number of square feet/seat for all rooms.

It may be that a particular lecture room has a reduced open capacity because a certain number of hours/week are reserved for conferences, laboratories, or other special purposes. The number of hours reserved is entered in the restricted hours column to indicate that lecture room is reserved for this amount

UNIVERSITY OF TORONTO

FIGURE 14

C.A.M.P.U.S. SIMULATION PLANNING ANALYSIS

UNIVERSITY LECTURE ROOM FACILITIES REPORT

TERM 1967-68

BUILDING NAME	BLDG. NO.	ROOM NO.	SEATS	FAC.,DEPT. AFFIL.		RES. HOURS	SQ. FT.	SQ. FT./SEAT	DEV. FROM AVG.
ANATOMY BUILDING	4	211	100.	-0	-0	-0.	1020.	10.2	-1.6
ANATOMY BUILDING	4	111	230.	-0	-0	-0.	2570.	11.2	-0.7
ARCHITECTURE BLDG	28	107	56.	-0	-0	-0.	836.	14.9	3.1
ARCHITECTURE BLDG	28	104	56.	-0	-0	-0.	709.	12.7	0.8
ARCHITECTURE BLDG	28	105	60.	-0	-0	-0.	714.	11.9	0.1
ARCHITECTURE BLDG	28	103	170.	-0	-0	-0.	1597.	9.4	-2.4
BANTING INSTITUTE	16	131	190.	-0	-0	-0.	2520.	13.3	1.4
BEST INSTITUTE	52	114	215.	-0	-0	-0.	1950.	9.1	-2.8
BOTANY BUILDING	11	203	35.	-0	-0	-0.	522.	14.9	3.1
BOTANY BUILDING	11	6	179.	-0	-0	-0.	1832.	10.2	-1.6
SCHOOL OF BUSINESS	38	209	14.	-0	-0	-0.	455.	32.5	20.7
SCHOOL OF BUSINESS	38	311	20.	-0	-0	-0.	450.	22.5	10.7
SCHOOL OF BUSINESS	38	203	85.	-0	-0	-0.	1021.	12.0	0.2
CONSERV. OF MUSIC	100	309A	8.	-0	-0	-0.	182.	22.8	10.9
CONSERV. OF MUSIC	100	329	20.	-0	-0	-0.	146.	7.3	-4.5
EDWARD JOHNSON	51	215	20.	-0	-0	-0.	493.	24.6	12.8
EDWARD JOHNSON	51	108	40.	-0	-0	-0.	548.	13.7	1.9
EDWARD JOHNSON	51	109	40.	-0	-0	-0.	566.	14.1	2.3
EDWARD JOHNSON	51	120	40.	-0	-0	-0.	499.	12.5	0.6
EDWARD JOHNSON	51	209	40.	-0	-0	-0.	526.	13.1	1.3
EDWARD JOHNSON	51	216	40.	-0	-0	-0.	644.	16.1	4.3
EDWARD JOHNSON	51	217	40.	-0	-0	-0.	534.	13.3	1.5
EDWARD JOHNSON	51	224	40.	-0	-0	-0.	473.	11.8	-0.0
EDWARD JOHNSON	51	225	40.	-0	-0	-0.	516.	12.9	1.1
EDWARD JOHNSON	51	78	75.	-0	-0	-0.	2190.	29.2	17.4
EDWARD JOHNSON	51	119	75.	-0	-0	-0.	2255.	30.1	18.2
EDWARD JOHNSON	51	116	108.	-0	-0	-0.	1235.	11.4	-0.4
EXTENSION DIVISION	50	108	80.	-0	-0	-0.	882.	11.0	-0.8
FOOD SCIENCES	15	312	48.	-0	-0	-0.	617.	12.9	1.0
FOOD SCIENCES	15	314	53.	-0	-0	-0.	676.	12.8	0.9
FOOD SCIENCES	15	216	60.	-0	-0	-0.	685.	11.4	-0.4
FOOD SCIENCES	15	218	74.	-0	-0	-0.	786.	10.6	-1.2
FOOD SCIENCES	15	24	90.	-0	-0	-0.	2134.	23.7	11.9
FOOD SCIENCES	15	117	125.	-0	-0	-0.	1319.	10.6	-1.3
FORESTRY BUILDING	27	209	35.	-0	-0	-0.	412.	11.8	-0.1
FORESTRY BUILDING	27	110	40.	-0	-0	-0.	420.	10.5	-1.3
FORESTRY BUILDING	27	301	73.	-0	-0	-0.	802.	11.0	-0.9
GALBRAITH BUILDING	70	116	30.	-0	-0	-0.	539.	18.0	6.1
GALBRAITH BUILDING	70	216	30.	-0	-0	-0.	644.	21.5	9.6
GALBRAITH BUILDING	70	314	30.	-0	-0	-0.	649.	21.6	9.8
GALBRAITH BUILDING	70	415	30.	-0	-0	-0.	649.	21.6	9.8
GALBRAITH BUILDING	70	119	102.	-0	-0	-0.	956.	9.4	-2.5
GALBRAITH BUILDING	70	120	102.	-0	-0	-0.	955.	9.4	-2.5
GALBRAITH BUILDING	70	220	102.	-0	-0	-0.	956.	9.4	-2.5
GALBRAITH BUILDING	70	221	102.	-0	-0	-0.	955.	9.4	-2.5
GALBRAITH BUILDING	70	244	102.	-0	-0	-0.	1059.	10.4	-1.5
GALBRAITH BUILDING	70	248	102.	-0	-0	-0.	1059.	10.4	-1.5
HYGIENE BUILDING	25	127	18.	-0	-0	-0.	214.	11.9	0.1
HYGIENE BUILDING	25	128	25.	-0	-0	-0.	302.	12.1	0.2

of time per week. The final column on the report is used to evaluate if a room corresponds to current standards for square feet/seat. A very large positive deviation indicates poor utilization of the space and possible need for renovation to meet the standards.

A summary of information contained in Figure 14 is shown in Figure 15 for rooms of each size range. If a new academic building containing several lecture rooms were to be proposed, the overall increase in university lecture room resources would be shown here.

During the matching process some rooms are found unsuitable for the requirements of departments near these rooms. These rooms remain in a central pool of rooms and are used to schedule any unmatched departmental room requirements. Both students and staff may have to walk further for classes, but the overall university seat utilization should be greater since departments with class sizes close to the room capacity will be scheduled in these rooms rather than in unsuitably small or large rooms in their own building. A partial listing of the unmatched available rooms is shown in Figure 16. A summary of the information for these rooms is given in Figure 17. The unmatched or unsatisfied room requirements are summed over all departments and compared to the rooms remaining to determine any excess or shortage by room size interval. Experiments on the model which

```
ABOVE LIST   PRESENTS LECTURE ROOMS AVAILABLE FOR THE CURRENT TERM

AVERAGE NUMBER OF SQ. FT. PER SEAT IS  195478.0/ 16573. = 11.8  DEVIATION FOR EACH ROOM IS MEASURED FROM THIS AVERAGE


                                        BREAKDOWN BY SIZE RANGE
                                        -----------------------

SIZE(STUDENTS)   NO. OF ROOMS   NO. OF SEATS   TOTAL ROOM-HOURS AVAIL.   NO. OF SQ. FT.   AVERAGE SQ. FT./SEAT   MEAN ROOM SIZE

   0. TO   20.        53.            807.              2915.0                13605.0             16.9                  15.2
  20. TO   60.        78.           3047.              4290.0                44551.0             14.6                  39.1
  60. TO  100.        46.           3726.              2530.0                46169.0             12.4                  81.0
 100. TO  180.        30.           3895.              1650.0                40775.0             10.5                 129.8
 180. TO  999.        20.           5098.              1100.0                50378.0              9.9                 254.9
                  -------      ---------          ----------           -----------          -------
            TOTAL  227    TOTAL  16573.     TOTAL  12485.0       TOTAL    195478.0  OVERALL AVG. 11.8
```

FIGURE 15

FIGURE 16

LECTURE ROOMS REMAINING IN THE CENTRAL ROOM POOL AFTER MATCHING

BUILDING NAME	BLDG. NO.	ROOM NO.	SEATS	RESTRICTED HOURS
ANATOMY BUILDING	4	211	100.	-0.
ANATOMY BUILDING	4	111	230.	-0.
ARCHITECTURE BLDG	28	103	170.	-0.
BANTING INSTITUTE	16	131	190.	-0.
BEST INSTITUTE	52	114	215.	-0.
BOTANY BUILDING	11	203	35.	-0.
BOTANY BUILDING	11	6	179.	-0.
SCHOOL OF BUSINESS	38	209	14.	-0.
SCHOOL OF BUSINESS	38	311	20.	-0.
SCHOOL OF BUSINESS	38	203	85.	-0.
EDWARD JOHNSON	51	108	40.	-0.
EDWARD JOHNSON	51	109	40.	-0.
EDWARD JOHNSON	51	120	40.	-0.
EDWARD JOHNSON	51	209	40.	-0.
EDWARD JOHNSON	51	216	40.	-0.
EDWARD JOHNSON	51	116	108.	-0.
ELECTRICAL BLDG	20	21	125.	-0.
ELECTRICAL BLDG	20	23	125.	-0.
ELECTRICAL BLDG	20	34	125.	-0.
EXTENSION DIVISION	50	108	80.	-0.
FOOD SCIENCES	15	312	48.	-0.
FOOD SCIENCES	15	314	53.	-0.
FOOD SCIENCES	15	216	60.	-0.
FOOD SCIENCES	15	218	74.	-0.
FOOD SCIENCES	15	24	90.	-0.
FOOD SCIENCES	15	117	125.	-0.
FORESTRY BUILDING	27	209	35.	-0.
FORESTRY BUILDING	27	110	40.	-0.
FORESTRY BUILDING	27	301	73.	-0.
GALBRAITH BUILDING	70	119	102.	-0.
GALBRAITH BUILDING	70	120	102.	-0.
GALBRAITH BUILDING	70	220	102.	-0.
GALBRAITH BUILDING	70	221	102.	-0.
GALBRAITH BUILDING	70	244	102.	-0.
GALBRAITH BUILDING	70	248	102.	-0.
HYGIENE BUILDING	25	128	25.	-0.
HYGIENE BUILDING	25	423	35.	-0.
HYGIENE BUILDING	25	129	50.	-0.
HYGIENE BUILDING	25	236	50.	-0.
HYGIENE BUILDING	25	103	150.	-0.
LASH MILLER BLDG	73	157	42.	-0.
LASH MILLER BLDG	73	155	50.	-0.
LASH MILLER BLDG	73	158	98.	-0.
LASH MILLER BLDG	73	161	128.	-0.
LASH MILLER BLDG	73	159	208.	-0.
LIBRARY SCIENCE B	83A	201	10.	-0.
LIBRARY SCIENCE B	83A	202	40.	-0.
LIBRARY SCIENCE A	83B	A	40.	-0.
LIBRARY SCIENCE A	83B	C	40.	-0.
LIBRARY SCIENCE A	83B	D	40.	-0.
LIBRARY SCIENCE A	83B	B	80.	-0.
MECHANICAL BLDG	20	336	12.	-0.
MECHANICAL BLDG	20	252	128.	-0.
MECHANICAL BLDG	20	254	128.	-0.
MECHANICAL BLDG	20	102	350.	-0.

```
                    UNIVERSITY COLLEGE      1       201F      30.        -0.
                    UNIVERSITY COLLEGE      1       204A      23.        -0.
                    UNIVERSITY COLLEGE      1       219       22.        -0.
                    UNIVERSITY COLLEGE      1       221       30.        -0.
                    UNIVERSITY COLLEGE      1       231       30.        -0.
                    UNIVERSITY COLLEGE      1       313       21.        -0.
                    UNIVERSITY COLLEGE      1       314       25.        -0.
                    UNIVERSITY COLLEGE      1       315       21.        -0.
                    UNIVERSITY COLLEGE      1        12H      70.        -0.
                    UNIVERSITY COLLEGE      1       101A      68.        -0.
                    UNIVERSITY COLLEGE      1       103       61.        -0.
                    UNIVERSITY COLLEGE      1       104      120.        -0.
                    UNIVERSITY COLLEGE      1       106      145.        -0.
                    UNIVERSITY COLLEGE      1       118       90.        -0.
                    UNIVERSITY COLLEGE      1       122      103.        -0.
                    UNIVERSITY COLLEGE      1       129       66.        -0.
                    UNIVERSITY COLLEGE      1       135       56.        -0.
                    UNIVERSITY COLLEGE      1       138      140.        -0.
                    UNIVERSITY COLLEGE      1       214       98.        -0.
                    UNIVERSITY COLLEGE      1       220       50.        -0.
                    UNIVERSITY COLLEGE      1       228       50.        -0.
                    WALLBERG BUILDING       8       116       69.        -0.
                    WALLBERG BUILDING       8       123      160.        -0.
                    WALLBERG BUILDING       8      1033      135.        -0.
                    WALLBERG BUILDING       8      1035      230.        -0.
                    WALLBERG BUILDING       8      2034      151.        -0.


                              BREAKDOWN BY SIZE RANGE
                              -----------------------

SIZE(STUDENTS)      NO. OF SEATS     NO. OF ROOMS REMAINING     TOTAL UNSATISFIED ROOM REQ.     DIFFERENTIAL

  0. TO  20.            188.                 11.0                          42.3                    -31.3
 20. TO  60.           1667.                 45.0                          39.6                      5.4
 60. TO 100.           3161.                 39.0                          13.4                     25.6
100. TO 180.           3441.                 27.0                           8.7                     18.3
180. TO 999.           4902.                 19.0                           2.9                     16.1
                                           ------
                                   TOTAL  141
```

FIGURE 17

affect the requirements for rooms (Examples 1-4) and the matching efficiency (Example 5) influence the reports shown in Figures 16 and 17. Therefore, this report extends the analysis of the implications of space planning decisions.

SECTION IV   OTHER APPLICATIONS

The foregoing investigations and experiments are just a few of the lecture room space planning decisions that may be assessed by the S.P.A.C.E.S. simulation model. For one example, if the number of room size intervals (NINT1) were increased, a new set of experiments could be run. For another, the search for rooms to fulfill a department's requirements could be restricted to that department's home building (NPRIOR = 1), then to include the nearest building (NPRIOR = 2), and so on, evaluating the extent to which that department's need for rooms is satisfied at each step. Also, the recent Macpherson Commission Report on undergraduate instruction in the Faculty of Arts and Science recommends a reduction in the number of classroom hours per week, and greater use of the small lecture-discussion classes of not more than thirty students. The implications of the proposals set forth in the report on present and future lecture, seminar, and tutorial room space could be simulated. Lecture room space that is currently poorly utilized could be identified, and the feasibility of partitioning a room into smaller modules of capacity thirty students could be studied. A simulation planning model for laboratory space is under development which will be able to evaluate the ramifications of the Macpherson Commission recommendations on laboratories.

This brief report illustrates computer-assisted techniques which may be applied to space planning, and the types of management information that could be provided to assist university administrators and planning committees in decision-making. Also, it may help university personnel to understand more fully the space planning problems of this large and complex university.

VII CONCLUSION

This lecture room planning model is an improvement and expansion of the elementary conceptual reports of the Space Requirements Section of C.A.M.P.U.S. More comprehensive planning information is provided. With the insertion of real rather than hypothetical data into the model, the reports display fact rather than conjecture, and are more meaningful to University administrators. Recent administrative decisions typify an increasing awareness of the problems of space management and planning, and an interest in the simulation model approach in evaluating alternative decisions. The Office of Institutional Research is currently developing detailed planning models for other types of space such as instructional laboratories, academic and administrative offices, residences, and libraries. The Physical Plant Department is engaged in building and maintaining a perpetual inventory of the University's physical facilities. Space standards and space planning factors provided from the inventory data will be used in the computer planning models. In addition, a Committee on Resource Planning has been formed by the President. The terms of reference of this committee include the investigation of increased utilization of existing space, and more systematic evaluation and planning of new facilities.

The thesis program runs on the Institute of Computer Science IBM 7094-II installation in approximately one minute per simulation period. Since the lecture room section occupies almost all of the available core storage (32K words) of the computer, successive models for other types of space will have to be overlayed. Presently, the lecture room model runs separately from the main CAMPUS program which requires the machine's nine tape units. The Office of Institutional Research has not decided whether to integrate the space planning models or run them separately using a data tape and/or punched cards produced by the main CAMPUS program. To facilitate integration into the structure of CAMPUS, the same variable names have been used for arrays which contain information produced by the Enrollment Formulation Section. The Institute of Computer Science is planning to install further IBM System 360 equipment which will provide much greater core storage capacity and simplify the complex nature of the overlaying of the many CAMPUS routines.

It is hoped that the information generated by this thesis project will be of special use to institutions developing formal space management and planning programs, particularly those which contemplate the use of the computer.

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APPENDIX A

Contents: Academic department codes

Major academic buildings by number

Glossary of variable names in alphabetic order

UNIVERSITY OF TORONTO
LECTURE ROOM PLANNING MODEL

ACADEMIC DEPARTMENT CODES

Arts and Science:

1. Anthropology
2. Astronomy
3. Botany
4. Chemistry
5. East Asian Studies
6. Fine Art
7. Geography
8. Geology
9. History
10. Islamic Studies
11. Italian and Hispanic Studies
12. Mathematics
13. Philosophy
14. Physics
15. Political Science and Economics
16. Psychology
17. Slavic Studies
18. Sociology
19. Zoology

University College:

20. Classics
21. English
22. Ethics
23. French
24. German
25. Near Eastern Studies

Applied Science and Engineering:

26. Chemical Engineering
27. Civil Engineering
28. Electrical Engineering
29. Industrial Engineering
30. Mechanical Engineering
31. Metallurgy and Materials Science
32. Aerospace Studies

33. School of Architecture
34. School of Business
35. Institute of Child Study

36. Institute of Computer Science
37. Faculty of Dentistry
38. Dental Hygiene
39. Faculty of Food Sciences
40. Faculty of Forestry
41. Faculty of Law
42. School of Library Science
43. Faculty of Music
44. School of Nursing
45. Faculty of Pharmacy
46. Physical and Health Education
47. School of Social Work

The following Faculties and Colleges were coded as follows:

Faculty Code	Faculties or College	Departments
1	Arts and Science	1-19
2	University College	20-25
3	Applied Science and Engineering	26-32

UNIVERSITY OF TORONTO
PHYSICAL PLANT DEPARTMENT CODES

MAJOR ACADEMIC BUILDINGS BY NUMBER

1.	University College
2.	Hart House
3.	Library
4.	Medical and Anatomy Building
5.	Medical Sciences Building
6.	Humanities Library
7.	Mining and Mill Building
8.	Metallurgy and Wallberg Building
9.	Old Physics Building
11.	Botany Building
14.	Ontario College of Education
15.	Household Science Building
16.	Banting Institute
17.	Royal Ontario Museum
20.	Electrical and Mechanical Building
25.	Hygiene Building
27.	Forestry Building
28.	School of Architecture
31.	Innis College
32.	New College
33.	Sidney Smith Hall
36.	School of Nursing
38.	School of Business
40.	Law Building
50.	Extension Division
51.	Edward Johnson Building
52.	Best Institute
53.	Institute of Child Study
61A.	Borden Building
62.	Erindale College
64.	Scarborough College
65.	Dental Building
67.	Superintendent's Building
68.	Benson Building
70.	Galbraith Building
72.	Ramsay Wright Laboratories
73.	Lash Miller Laboratories
77.	Sussex Court
78A.	New Physics Building
79.	Pharmacy Building
83A.	Library Science
83B.	Library Science
100.	Royal Conservatory of Music

GLOSSARY OF VARIABLE NAMES

Name	Meaning	Maximum Dimension
AMIDPT	The midpoints of the lecture room size intervals.	(7)
AMTØFF	A departmental percentage used to reduce a department's room requirements in the smallest size interval, recognizing that a certain % of these small classes are taught in professors' offices.	(100)
ASSIGN	A departmental array used to add rooms of the smallest size range to a department's requirements if rooms are required for conferences and other uses beyond the department's teaching space needs.	(100)
AVGINT	The average number of square feet per seat in each lecture room size interval.	(7)
AVGISS	The average section (class) size for each department in each room size range. This number is the weighted average of the various class sizes that contribute room-hours to that particular size interval.	(100,7)
AVGSQF	The average number of square feet per seat for all lecture rooms in the University.	
BBLDG	Name of a University building in the sub-inventory of lecture rooms.	(250)
BEST	The minimum value of the array SUTILZ, and representing the room with a calculated seat utilization closest to but not equal to 100%. BEST is calculated when no suitable room of less than 100% seat utilization is found.	
BINT	The room size interval end points.	(8)
BLDG	The name of a University building in the complete lecture room inventory.	(250)
BLDPER	The percentage of lecture rooms in a building tagged as suitable to fulfill a department's room requirements.	
BLDPRI	An array containing for each department a list of up to five building numbers. The first building is the building of first priority for satisfying the department's room requirements (usually the building where the department is located). The second building	(100,5)

Name	Meaning	Maximum Dimension
	is next in priority and usually the most neighbouring building, and so on. A building number of ZERO indicates a search will be made for appropriate rooms anywhere on campus.	
CCOST	- The computed construction cost of lecture rooms in each size interval.	(7)
CINT	- The size interval end points adjusted by a factor of 100.0/SUTIL.	(8)
COSTIN	- Academic building construction cost index. $/square foot.	
COSTOT	- The total construction cost of building the required lecture room facilities.	
CPDEV	- The deviation between CPRMS and UNSATI in number of rooms for each size interval.	(7)
CPRMHR	- The number of room-hours still available in rooms of each size interval in the central room pool after the matching process.	(7)
CPRMS	- The number of rooms in each size interval remaining in the central room pool after the matching process.	(7)
CPSEAT	- The number of seats remaining in rooms of each size interval left in the central room pool after the matching process.	(7)
CSQFT	- The number of square feet of lecture room space required by the University in each size range.	(7)
DEVIAT	- The deviation of the statistic SQPERS from the average number of square feet/seat for all University lecture rooms.	(250)
DIFFHR	- For each room size range, the difference between the total number of room-hours required by all departments and the total number of room-hours available in University lecture rooms.	(7)
DIFFRM	- For each room size interval, the difference between the total number of rooms required by all departments and the total number of lecture rooms available on campus.	(7)

Name	Meaning	Maximum Dimension
DINT	- The size interval end points adjusted by a factor of 100.0/SULØWD.	(8)
DIST	- An array containing a distribution representing the percentage of the forecasted total number of enrollees, for a particular department and academic year, in each lecture room size range. An input distribution is not supplied when a department's class sizes are all in one size range, as the average class size is used.	(250,7)
DPNAME	- The name of a department.	(100,4)
DRUTIL	- Departmental room utilization.	(100)
EFFMAT	- The matching efficiency attained averaged over all size intervals.	
EFFSAT	- The percentage of unsatisfied room requirements fulfilled by rooms remaining in the central room pool averaged over all size intervals.	
FACHRS	- The total number of room-hours required by size interval for each Faculty.	(20,7)
FACNAM	- The names of the Faculties for which summary reports are given.	(20,4)
FACRMS	- The total number of rooms required in each size interval for each Faculty.	(20,7)
FØUND	- An indicator whether a room has been found during the matching process to satisfy a department's room requirement. If FØUND = 0.0, no room has been found. If FØUND = 1.0, a suitable room has been found.	
HL	- The average number of hours/week/subject for each academic year of each department.	(100,9)
HRDEV	- The deviation of HRUTIL from the average University room utilization.	(7)
HRLACK	- The actual excess or shortage of room-hours by size interval based on the deviation from the expected average University room utilization.	(7)
HRUTIL	- Room-hour utilization by size interval (TRMHRS/RMHRTØ) * 100 percent.	(7)

Name	Meaning	Maximum Dimension
IACA	- The maximum number of academic years in a department. For the University of Toronto this number is 9 - 3 general years, 5 honour years, and 1 year for graduate studies.	
IBEGIN	- The beginning year of the simulation analysis, e.g. 66 for 1966.	
ICØUNT	- A variable representing the number of buildings searched for rooms to satisfy a department's needs. The program starts to search first through the department's home building (ICØUNT = 1), then on to the most neighbouring building (ICØUNT = 2), and so on until ICØUNT = ITERAT.	
IEND	- The final simulation year.	
INIT1	- The lower year number in a given session, e.g. Session 1967-68, INIT1 = 67.	
INIT2	- The upper year number for a given session. INIT2 = INIT1 + 1.	
ISIMYR	- Integer equivalent of SIMYR.	
ITERAT	- A counter representing the number of iterations through the list of departments the program has completed in the search to satisfy departmental room requirements of a particular size.	
ITEST	- A variable that is tested to see if a distribution of enrollee breakdown is input for a given department and academic year. If ITEST = 0, a distribution is not present. If ITEST = 1, a distribution is supplied.	(100,9)
LBLDG	- Number of a University building in the sub-inventory of lecture rooms.	(250)
LCHECK	- A variable to check if a room in the sub-inventory of lecture rooms has been assigned to a department. If LCHECK = 0, the room is not assigned yet. If LCHECK = 1, the room has been assigned.	(250)
LFAC	- The faculty number in the sub-inventory of rooms.	(250)
LØDEPT	- The department number in the sub-inventory of lecture rooms.	(250)

Name	Meaning	Maximum Dimension
LRES	- The number of hours of restricted usage for rooms in the sub-inventory of lecture rooms.	(250)
LROOM	- The room number for rooms in the sub-inventory of lecture rooms.	(250)
LUPDATE	- The updating code associated with rooms in the sub-inventory of lecture rooms.	(250)
MATCHE	- The total number of rooms to be matched in each size interval.	(7)
MROUND	- The number of the matching process currently being performed by the optimization routine.	
NBLDG	- The University of Toronto Physical Plant Department building number.	(250)
NCHECK	- A check bit to see if a room has been assigned to a department. If NCHECK = 0, the room is not assigned. If NCHECK = 1, the room has been assigned.	(250)
NDIST	- The total number of distributions supplied to modify the enrollee totals for the academic years of all departments.	
NDP	- The number of academic or teaching departments in the University.	
NFAC	- The faculty number associated with a lecture room.	(250)
NFACUL	- The number of faculties for which summary reports are printed.	
NINT1	- The number of lecture room size intervals being considered.	
NINT2	- The number of size interval end points. NINT2 = NINT1 + 1.	
NODEPT	- The department number associated with a lecture room.	
NOINCP	- The total number of rooms remaining in the central pool of rooms.	
NOTFND	- An indicator set equal to 1 if rooms were found to fulfill a department's requirements. If no suitable rooms were found, NOTFND = 0.	

Name	Meaning	Maximum Dimension
NØTMAT	- The total number of unmatched rooms in each size interval.	(7)
NPRIØR	- The number of buildings in the building priority lists for the various departments.	
NRES	- The number of weekly hours of restricted usuage for a lecture room. If a room is used 9 hours a week as a lab or conference room then NRES = 9 for that room.	(250)
NRØØM	- The lecture room door number.	(250)
NTAG	- The total number of lecture rooms in the sub-inventory of rooms generated by the updating routine for a particular Session.	
NTØTAL	- The total number of rooms in the lecture room inventory. This includes rooms projected for construction in future years, rooms being renovated, and rooms that are being torn down in the future.	
NUPDTE	- Lecture room updating code. NUPDTE = 000. Indicates no change in room status. The room is included in the sub-inventory each year. NUPDTE = 167. The "1" indicates addition. Add the room to the lecture room inventory in the session indicated by the last two digits (i.e. Session 67 - 68). NUPDTE = 270. The "2" indicates the razing of a room in a particular session. Delete the room in the session 70 - 71. NUPDTE = 368. The "3" indicates the room is to be temporarily removed from the lecture room inventory for that session. The assumption is made that it never takes longer than one session to renovate a room.	(250)
ØVERSU	- The overall average of the computed seat utilizations for matched rooms.	
PERMAT	- The percentage of rooms matched versus the number of rooms to be matched for each size interval.	(7)
PERSAT	- The percentage of unsatisfied room requirements of each size fulfilled by rooms of that size remaining in the central room pool.	(7)
REMRMS	- The unsatisfied room requirements for a given department and size interval after the matching process has been completed.	(100,7)

Name	Meaning	Maximum Dimension
RMDIFF	- An array containing the values of the DIFFRM array over all the years simulated.	(10,7)
RMHRS	- The number of room-hours required by a department in each room size interval.	(100,7)
RMHRT0	- The total number of room-hours available in rooms of each size range.	(7)
RMSASN	- A running count of the number of rooms matched in each size interval during the matching process. If this number equals the number of rooms available of a particular size, the program ceases to match rooms of that size.	(7)
RMT0T	- The total number of University lecture rooms of each size range available.	(7)
RMT0TC	- The total number of lecture rooms of each size range available using the adjusted size intervals. (Use end points CINT instead of BINT).	(7)
RMT0TD	- The total number of lecture rooms available in each adjusted size range. (Use end points DINT instead of BINT).	(7)
R0LEED	- The number of enrollees in each room size interval after multiplication of the array R0LEES by the array DIST.	(250,7)
R0LEES	- The number of enrollees in each academic year for each department.	(100,9)
R0MEAN	- The mean number of seats in lecture rooms of each size range.	(7)
R0MHRS	- The number of room-hours required for a given department and academic year. Calculated using an average class size, and added to the number of room-hours calculated using enrollee distributions.	(100,9)
R0UND	- Real equivalent of MR0UND.	
BR00MS	- The number of lecture rooms required by a department in each room size interval.	(100,7)

Name	Meaning	Maximum Dimension
RTSIZE	- The maximum value of the array SUTILZ, representing the room with a seat utilization closest to but not greater than 100%.	
RUTIL	- The average room utilization attained by the University with its present scheduling sophistication.	
SEATØT	- The total number of lecture room seats available in each room size range.	(7)
SEATS	- The number of seats in a lecture room.	(250)
SIMYR	- The number of academic sessions simulated.	
SKIP	- A program control parameter. If SKIP = 0.0, the complete program is executed. If SKIP = 1.0, subroutine MATCH is not executed, and the departmental matching reports are not printed.	
SQFT	- The area of a lecture room in square feet.	(250)
SQFTØT	- The total square footage available in lecture rooms of each size interval.	(7)
SQPERS	- The number of square feet/seat in each lecture room.	(250)
SSEATS	- The number of seats in a room in the sub-inventory of lecture rooms.	(250)
SSQFT	- The square footage of a room in the sub-inventory of lecture rooms.	(250)
SSTØP	- A program control parameter. If SSTØP = 0.0, the matching optimization routine is suppressed and the user must supply a value of SUTAL. If SSTØP = 1.0, the optimization routine starts at SUTAL and searches for the best match, decreasing SUTAL by THIS on each iteration.	
STØREU	- An array used to store the value of seat utilization computed when a room is matched with a department's needs.	(250)

Name	Meaning	Maximum Dimension
STR	- The forecasted class sizes in each academic year of every department.	(100,9)
SUL0W	- The lowest tolerable level of overall University seat utilization.	
SUL0WD	- Seat utilization parameter for the University-wide matching process. Used to adjust the room size interval end points.	
SUMMAX	- The sum of EFFSAT + EFFMAT + 0VERSU. This variable is maximized in the matching process optimization routine.	(20)
SUSIZE	- The average seat utilization attained in each room size interval after the matching of room requirements to available rooms.	(7)
SUTAL	- Starting seat utilization for the matching process.	
SUTIL	- Seat utilization parameter used in the matching process when SST0P = 1.0.	
SUTILZ	- An array used to store computed seat utilizations when searching for rooms.	(250)
TEAWK	- Departmental teaching week length (hours).	(100)
THIS	- Seat utilization decrement in the optimization routine for the matching process.	
T0TALA	- The total number of available lecture room seats on the St.George Campus.	
T0TALB	- The total square footage of lecture room space on the St.George Campus.	
T0TALC	- The total number of room-hours available.	
TRMHRS	- The total number of room-hours required in each size interval.	(7)
UNSATI	- The total unsatisfied room requirements in each size range. Includes fractional requirements and unmatched rooms.	(7)
URMS	- The total number of lecture rooms required by the University in each size interval.	(7)

Name	Meaning	Maximum Dimension
UTEAWK	- The University average teaching week length (hours).	
XASIGN	- The number of lecture rooms in a building matched to departments' needs.	
XC0UNT	- The number of lecture rooms in a building.	

APPENDIX B

Contents: Meaning of symbols used in program flowcharts

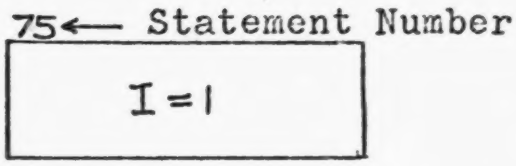
Skeleton of the CAMPUS model space requirements section

Diagram of the overall program structure

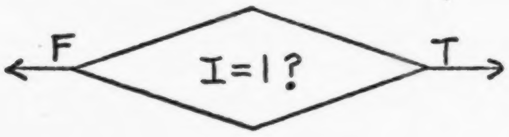
Overall subroutine flowchart, detailed logic flowchart, and program listing for:

- the main program
- subroutine FACIL
- subroutine ORCAST
- subroutine UWIDE
- subroutine MATCH
- subroutine SEARCH

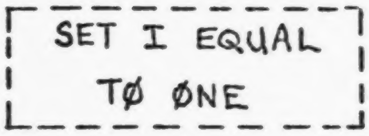
MEANING OF SYMBOLS USED IN PROGRAM FLOWCHARTS


75
Statement Number
I=1

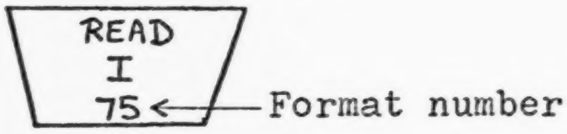
Processing



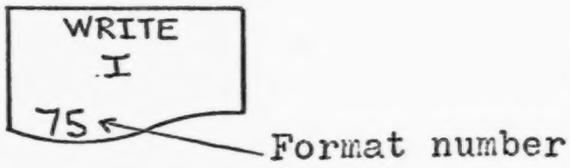
Logical IF statement


SET I EQUAL TØ ØNE

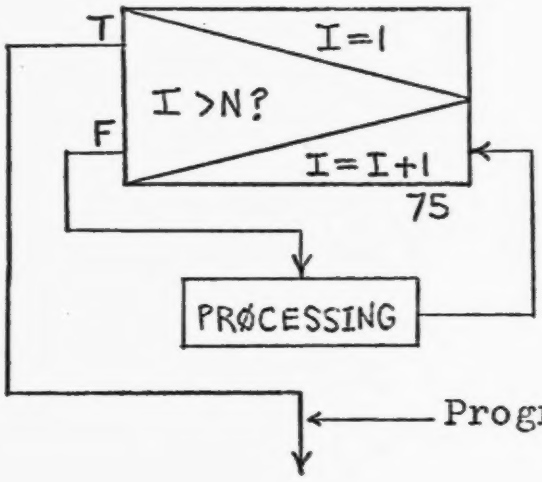
Comments


READ
I
75
Format number

Read statement


WRITE
I
75
Format number

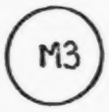
Write statement


T
I=1
I>N?
F
I=I+1
75
PRØCESSING

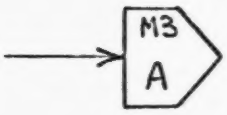
DO loop

```
DO  75  I = 1, N
====
====

75 CONTINUE
```

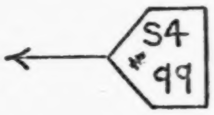
Program sequence or GO TO statement



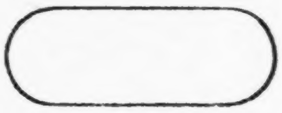
Page connector



'To' statement connector (e.g. transfer from this page <u>to</u> position A on page M3)

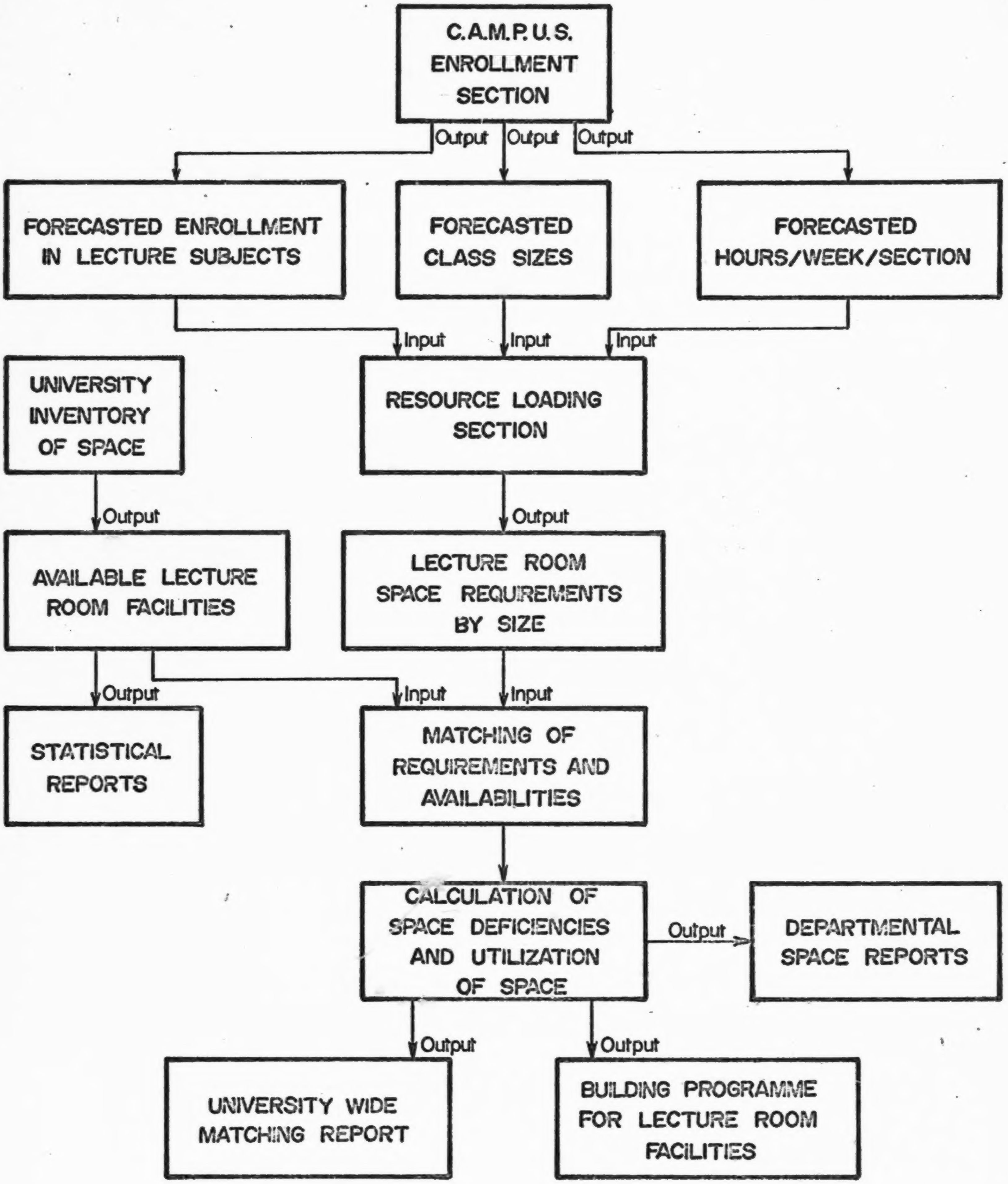


'From' statement connector (e.g. <u>from</u> page S4 to statement number 99 on this page)



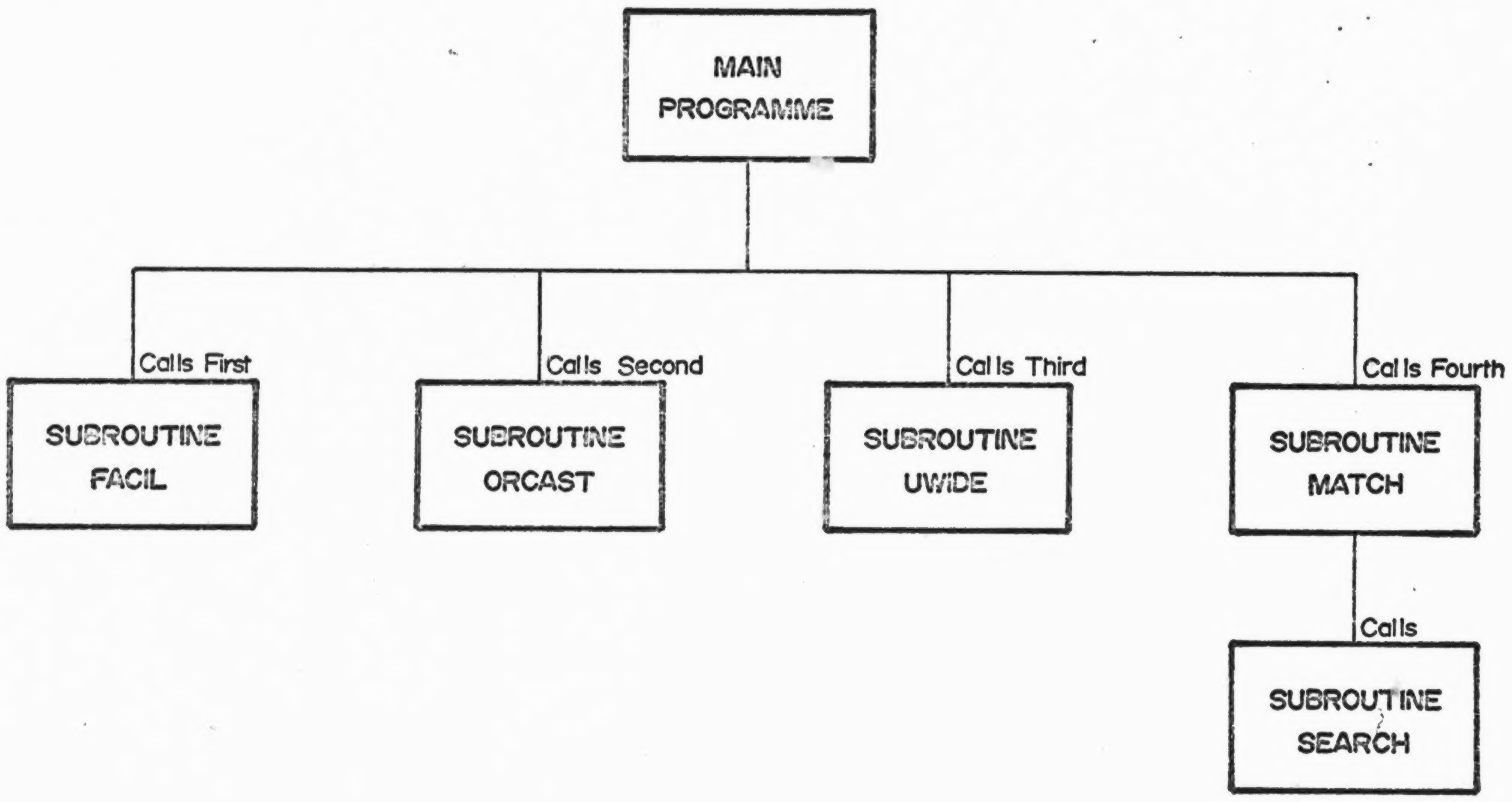
Enter or return from a subroutine. STOP and END statements.

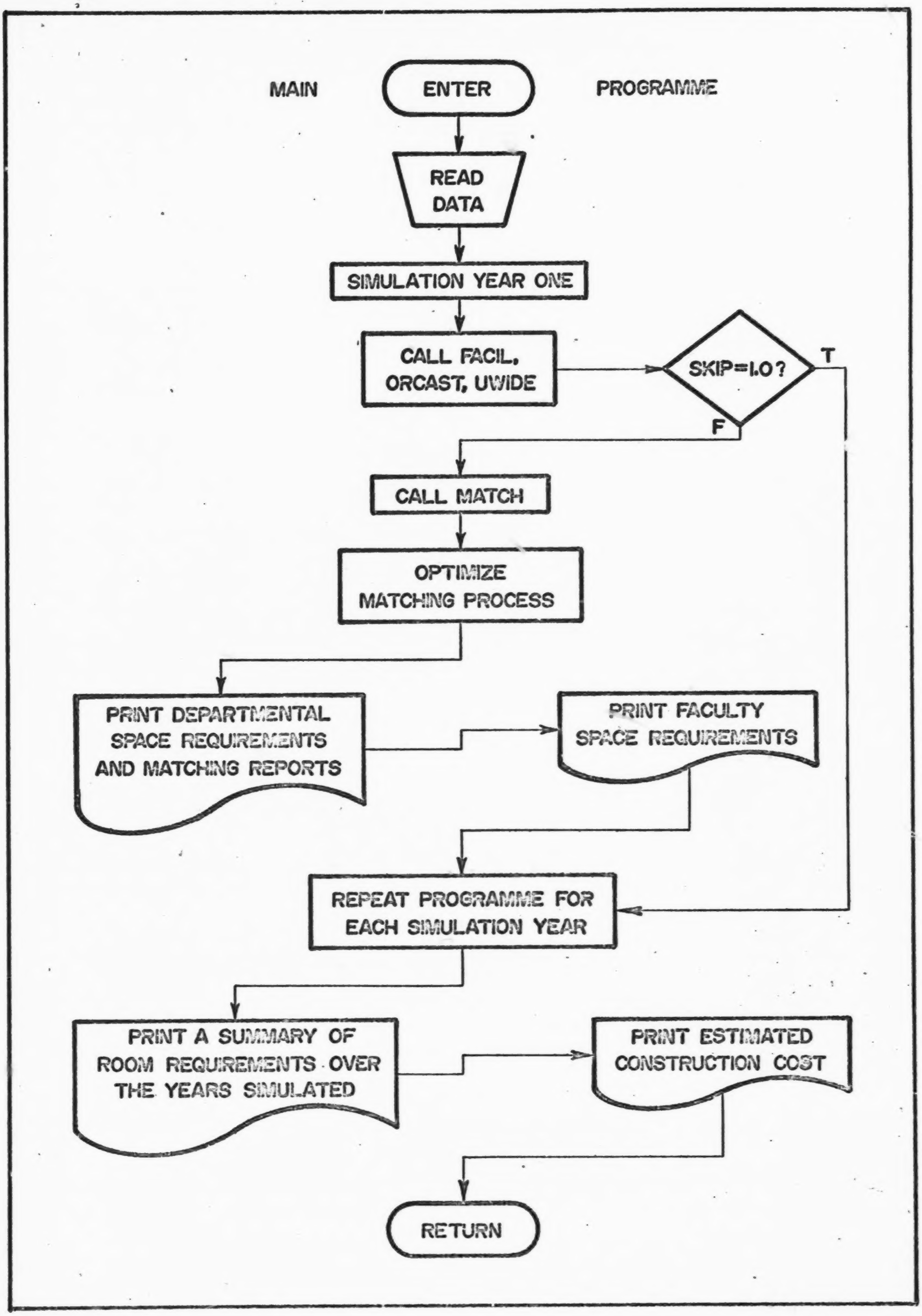
MP - Main program
F - Subroutine FACIL
O - Subroutine ORCAST
U - Subroutine UWIDE
M - Subroutine MATCH
S - Subroutine SEARCH

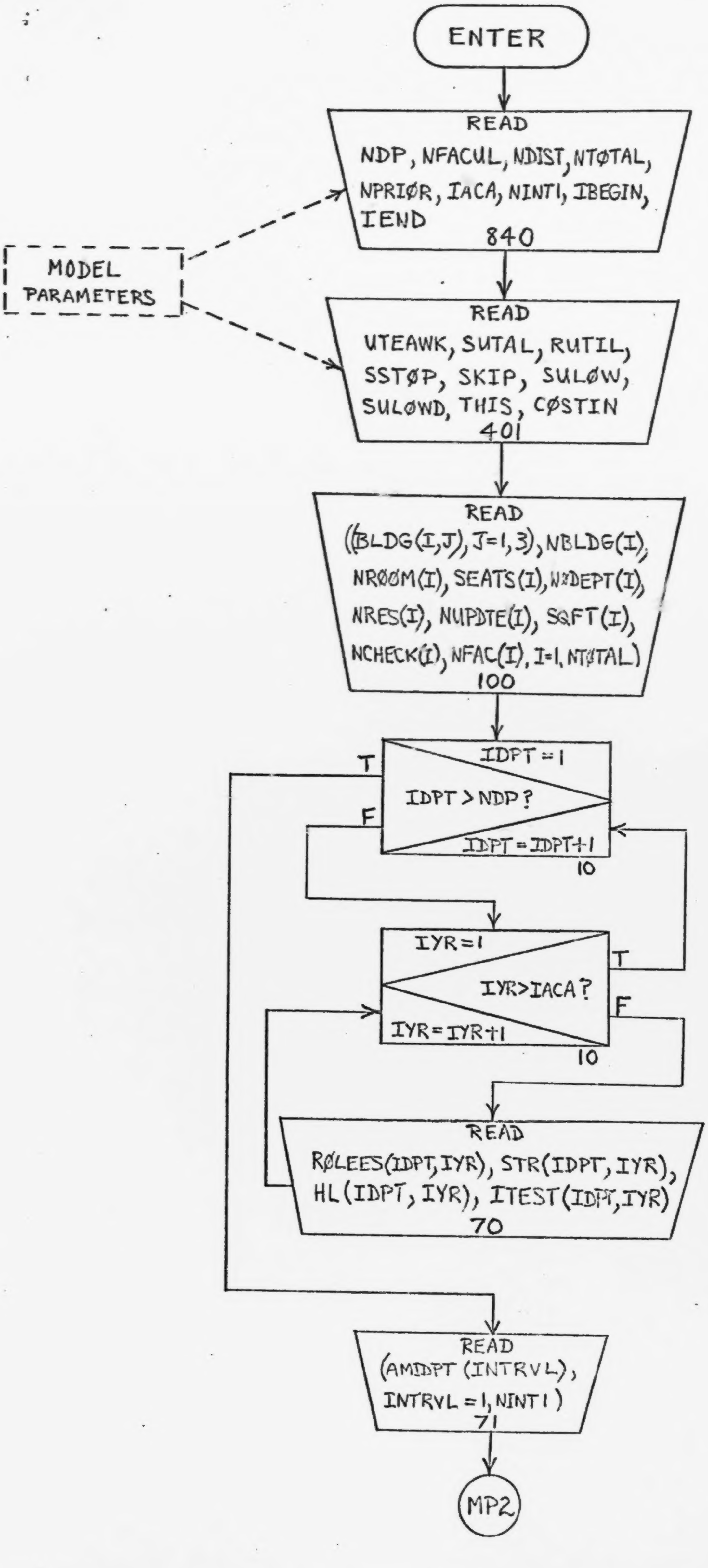

C.A.M.P.U.S. ENROLLMENT SECTION
Output
Output
Output
FORECASTED ENROLLMENT IN LECTURE SUBJECTS
FORECASTED CLASS SIZES
FORECASTED HOURS/WEEK/SECTION
Input
Input
Input
UNIVERSITY INVENTORY OF SPACE
RESOURCE LOADING SECTION
Output
Output
AVAILABLE LECTURE ROOM FACILITIES
LECTURE ROOM SPACE REQUIREMENTS BY SIZE
Output
Input
Input
STATISTICAL REPORTS
MATCHING OF REQUIREMENTS AND AVAILABILITIES
CALCULATION OF SPACE DEFICIENCIES AND UTILIZATION OF SPACE
Output
DEPARTMENTAL SPACE REPORTS
Output
Output
UNIVERSITY WIDE MATCHING REPORT
BUILDING PROGRAMME FOR LECTURE ROOM FACILITIES

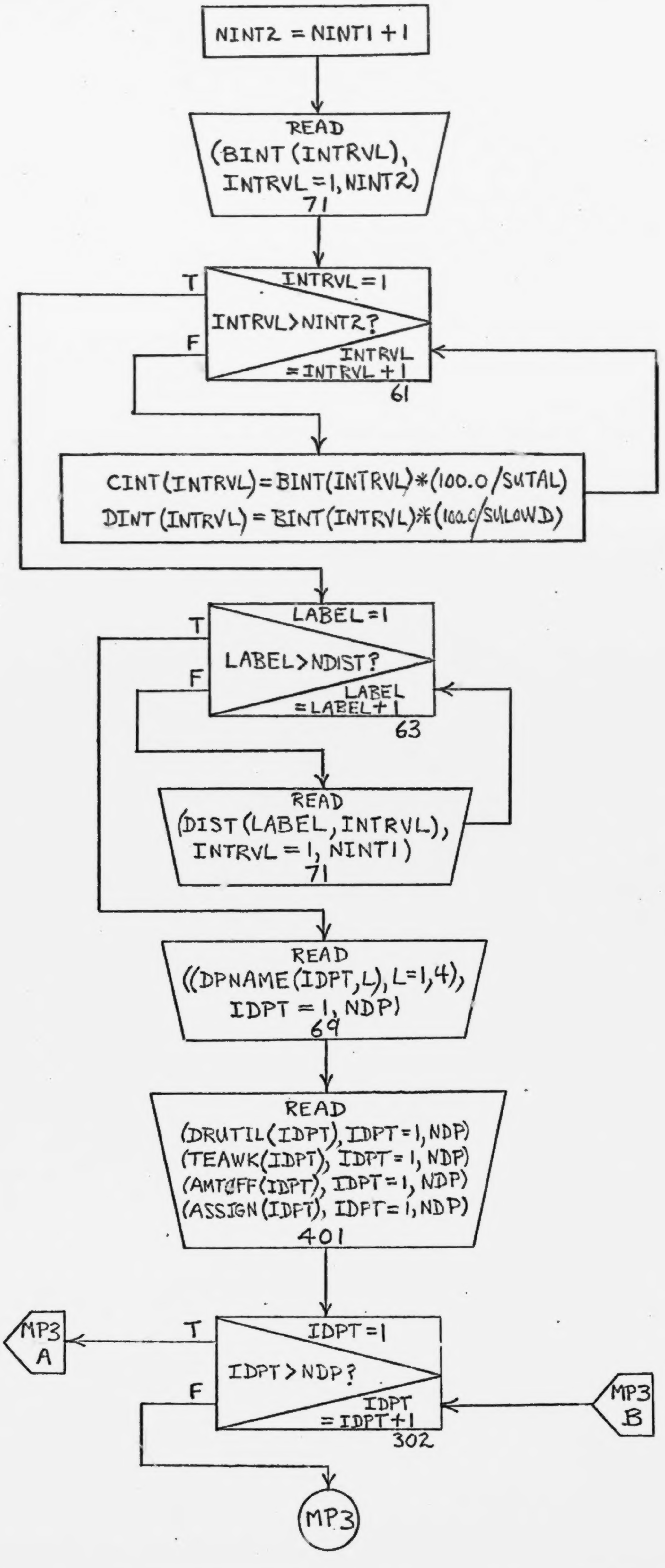
SKELETON OF S.P.A.C.E.S.
C.A.M.P.U.S. MODEL SPACE REQUIREMENTS SECTION

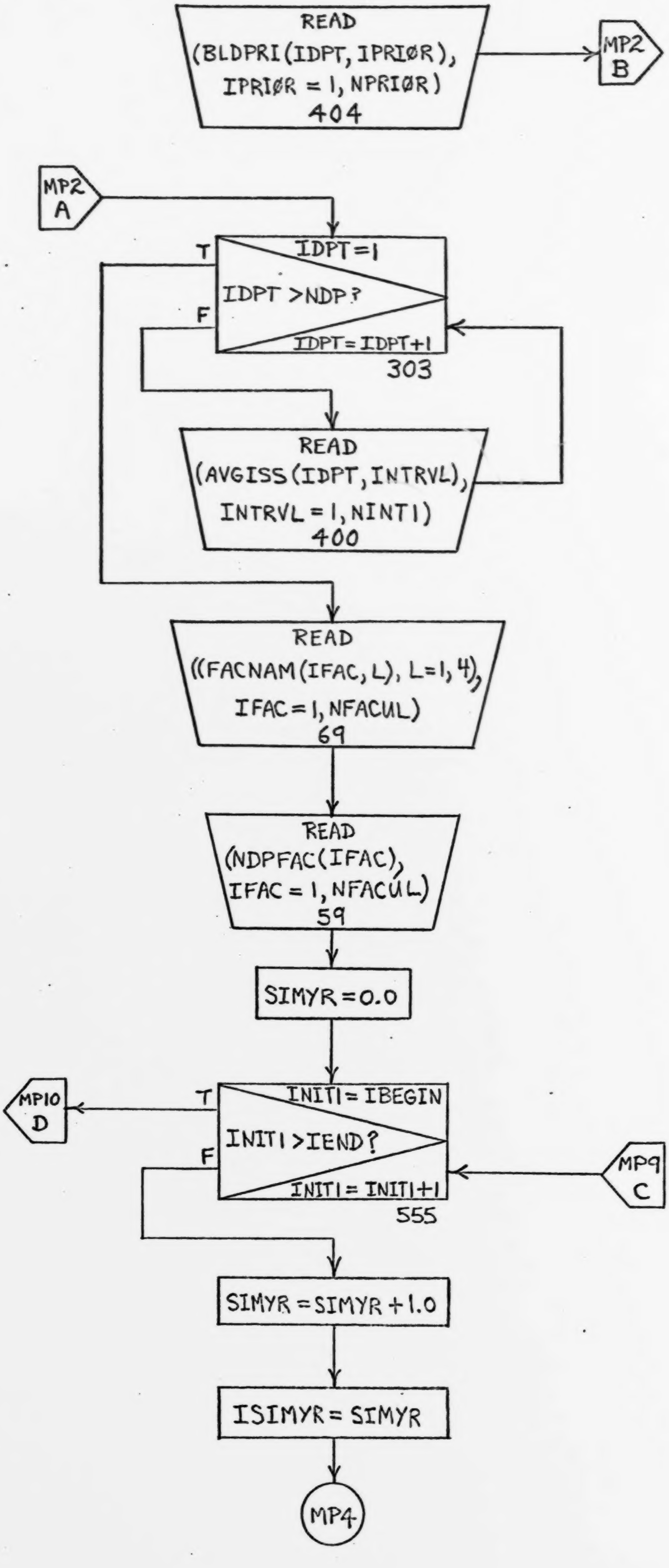
OVERALL PROGRAMME STRUCTURE


MAIN PROGRAMME
Calls First
SUBROUTINE FACIL
Calls Second
SUBROUTINE ORCAST
Calls Third
SUBROUTINE UWIDE
Calls Fourth
SUBROUTINE MATCH
Calls
SUBROUTINE SEARCH

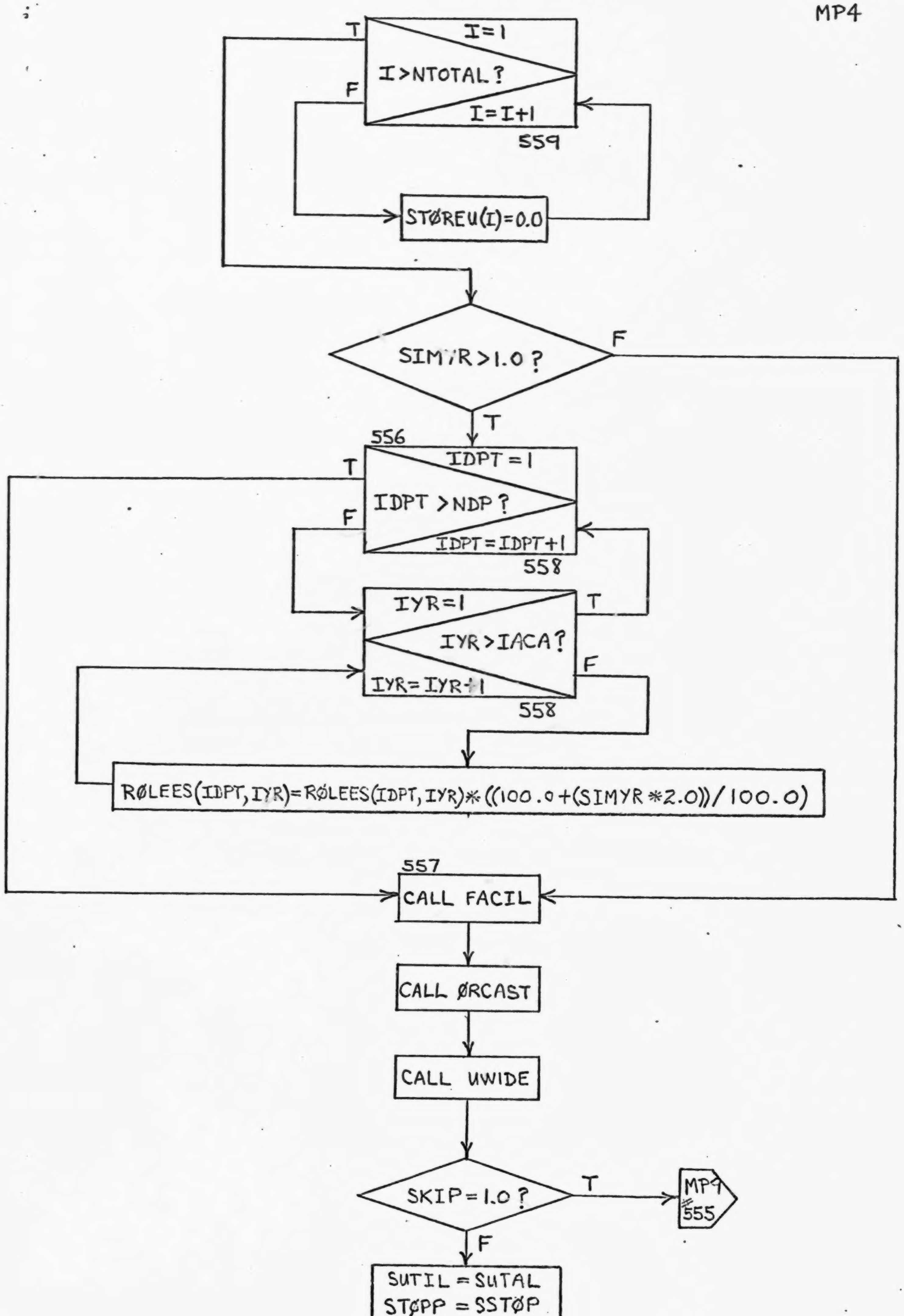

MAIN
ENTER
PROGRAMME
READ DATA
SIMULATION YEAR ONE
CALL FACIL, ORCAST, UWIDE
SKIP=1.0?
T
F
CALL MATCH
OPTIMIZE MATCHING PROCESS
PRINT DEPARTMENTAL SPACE REQUIREMENTS AND MATCHING REPORTS
PRINT FACULTY SPACE REQUIREMENTS
REPEAT PROGRAMME FOR EACH SIMULATION YEAR
PRINT A SUMMARY OF ROOM REQUIREMENTS OVER THE YEARS SIMULATED
PRINT ESTIMATED CONSTRUCTION COST
RETURN

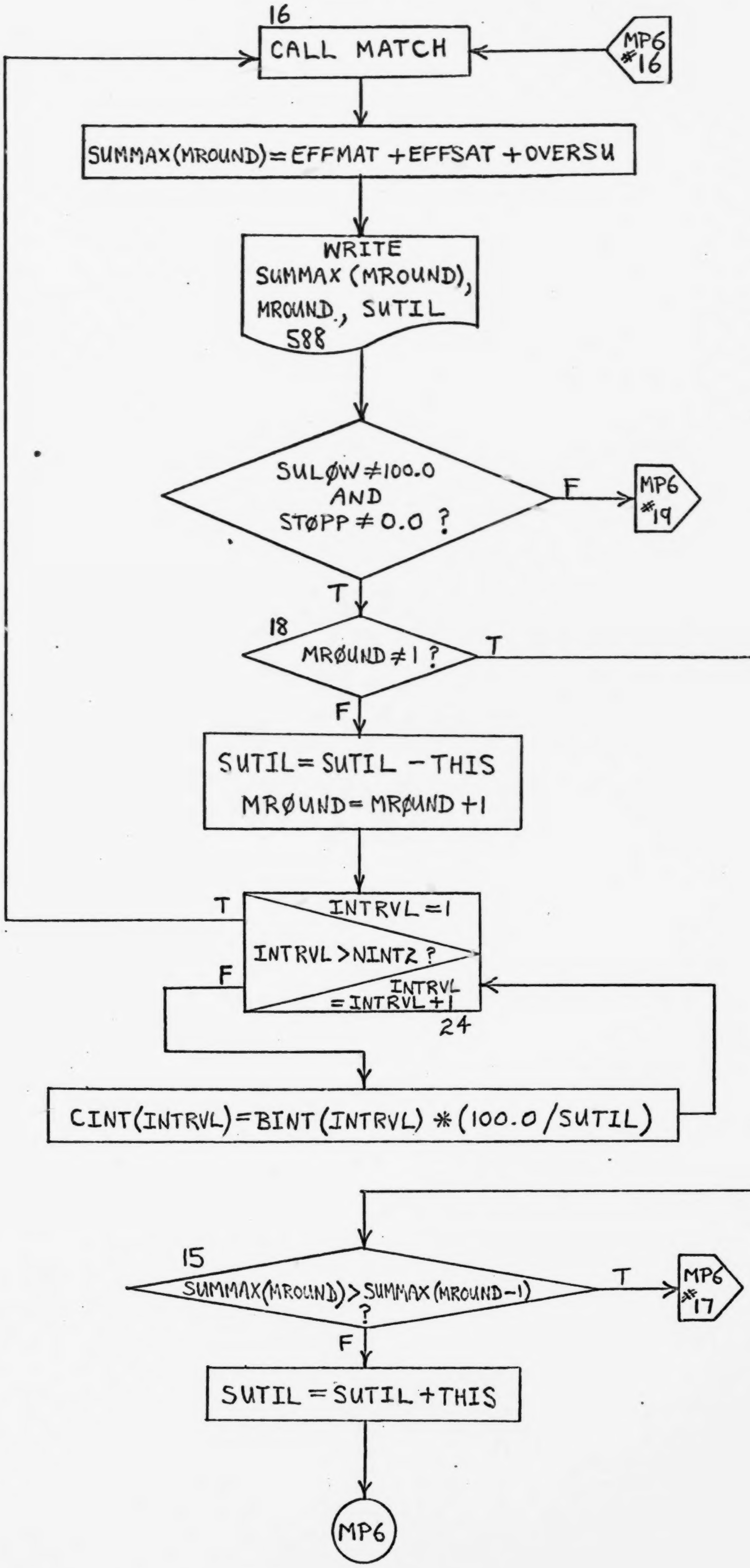

ENTER
MODEL PARAMETERS
READ
NDP, NFACUL, NDIST, NTØTAL, NPRIØR, IACA, NINT1, IBEGIN, IEND
840
READ
UTEAWK, SUTAL, RUTIL, SSTØP, SKIP, SULØW, SULØWD, THIS, CØSTIN
401
READ
((BLDG(I,J), J=1,3), NBLDG(I), NRØØM(I), SEATS(I), NØDEPT(I), NRES(I), NUPDTE(I), SQFT(I), NCHECK(I), NFAC(I), I=1, NTØTAL)
100
T
F
IDPT = 1
IDPT > NDP?
IDPT = IDPT+1
10
IYR = 1
IYR > IACA?
IYR = IYR+1
T
F
10
READ
RØLEES(IDPT, IYR), STR(IDPT, IYR), HL(IDPT, IYR), ITEST(IDPT, IYR)
70
READ
(AMIDPT (INTRVL), INTRVL = 1, NINT1)
71
MP2

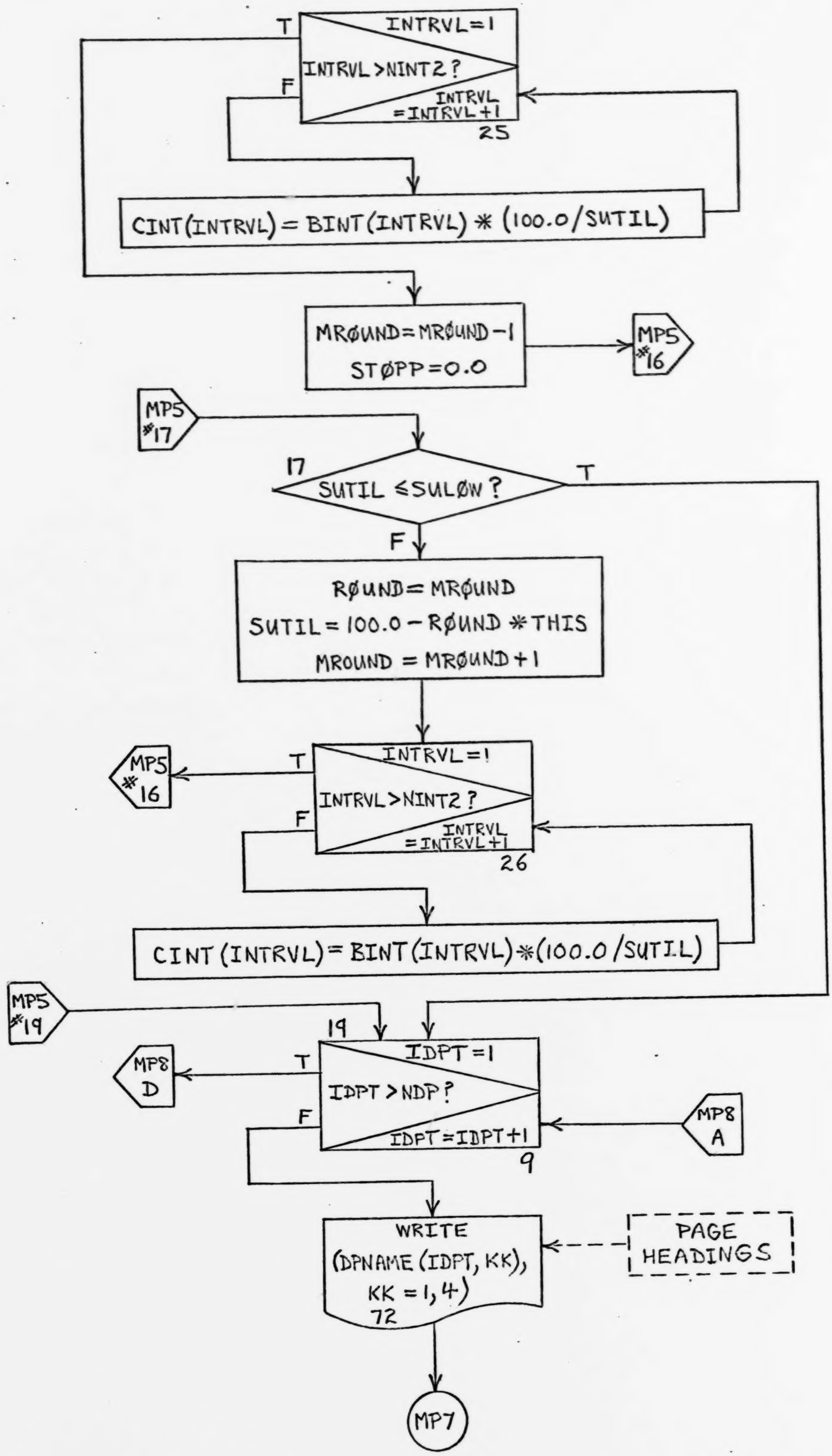

NINT2 = NINT1 + 1
READ
(BINT (INTRVL),
INTRVL = 1, NINT2)
71
T
INTRVL = 1
INTRVL > NINT2?
F
INTRVL
= INTRVL + 1
61
CINT (INTRVL) = BINT (INTRVL) * (100.0 / SUTAL)
DINT (INTRVL) = BINT (INTRVL) * (100.0 / SULOWD)
T
LABEL = 1
LABEL > NDIST?
F
LABEL
= LABEL + 1
63
READ
(DIST (LABEL, INTRVL),
INTRVL = 1, NINT1)
71
READ
((DPNAME (IDPT, L), L = 1, 4),
IDPT = 1, NDP)
69
READ
(DRUTIL (IDPT), IDPT = 1, NDP)
(TEAWK (IDPT), IDPT = 1, NDP)
(AMTØFF (IDPT), IDPT = 1, NDP)
(ASSIGN (IDPT), IDPT = 1, NDP)
401
MP3
A
T
IDPT = 1
IDPT > NDP?
F
IDPT
= IDPT + 1
302
MP3
B
MP3

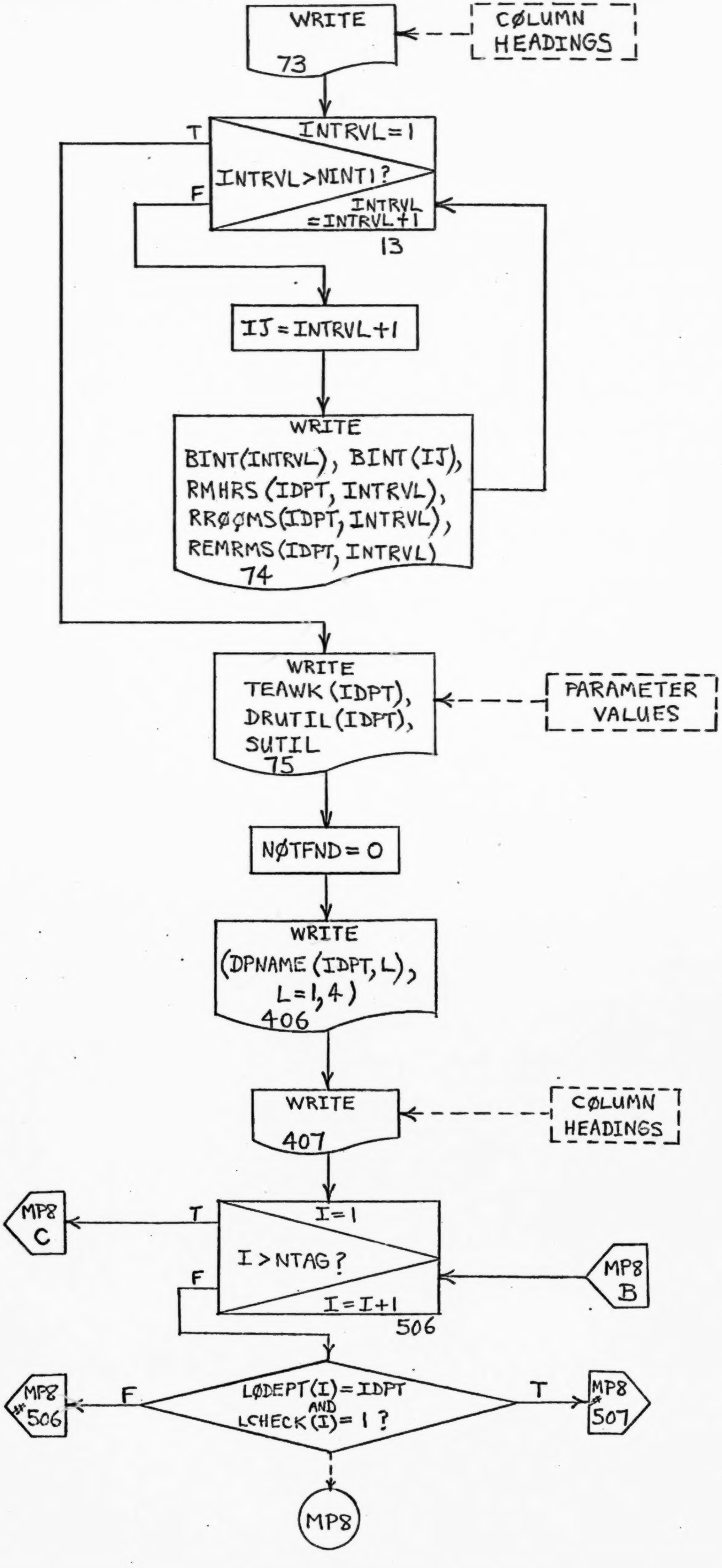

READ
(BLDPRI(IDPT, IPRIØR),
IPRIØR = 1, NPRIØR)
404
MP2
B
MP2
A
IDPT=1
IDPT >NDP?
IDPT = IDPT+1
T
F
303
READ
(AVGISS(IDPT, INTRVL),
INTRVL = 1, NINT1)
400
READ
((FACNAM(IFAC, L), L=1, 4),
IFAC = 1, NFACUL)
69
READ
(NDPFAC(IFAC),
IFAC = 1, NFACUL)
59
SIMYR = 0.0
INIT1 = IBEGIN
INIT1 >IEND?
INIT1 = INIT1+1
T
F
555
MP10
D
MP9
C
SIMYR = SIMYR + 1.0
ISIMYR = SIMYR
MP4

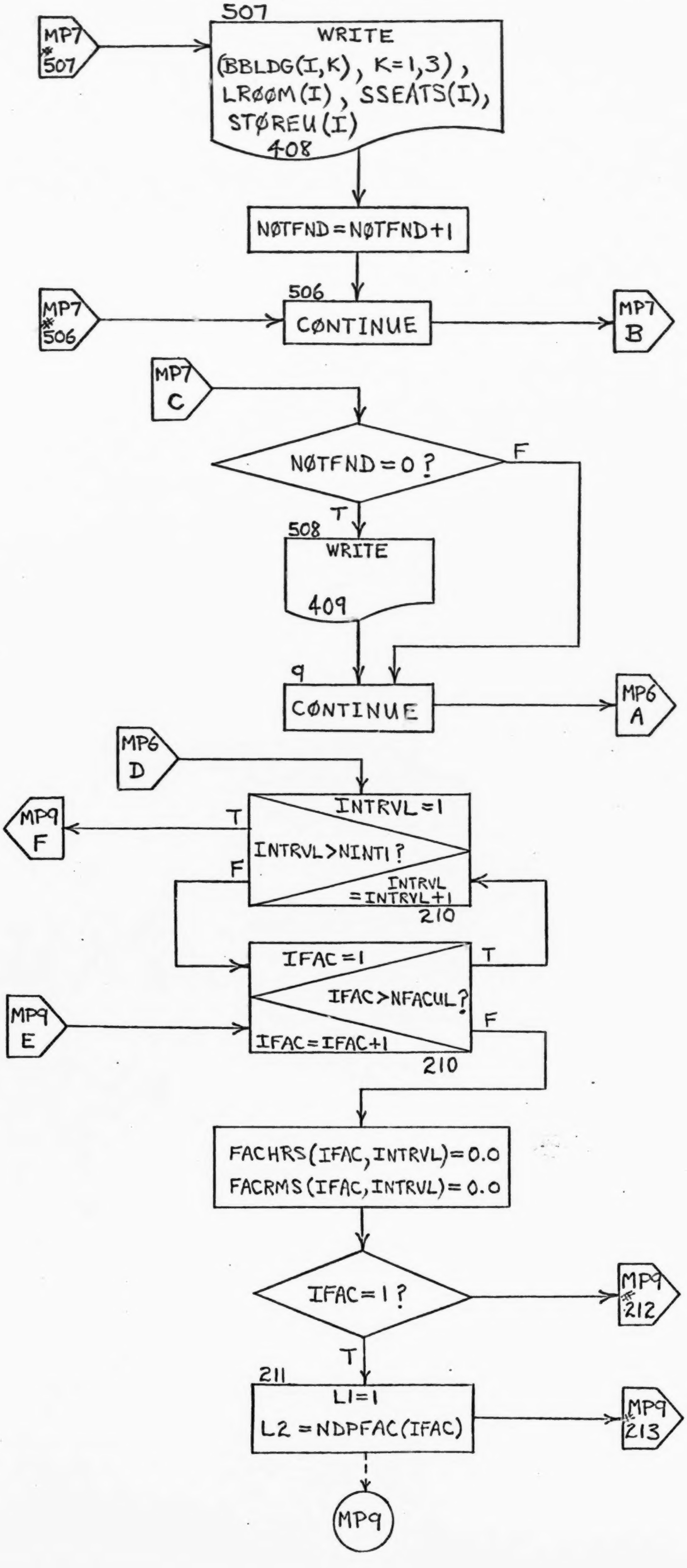
MP4

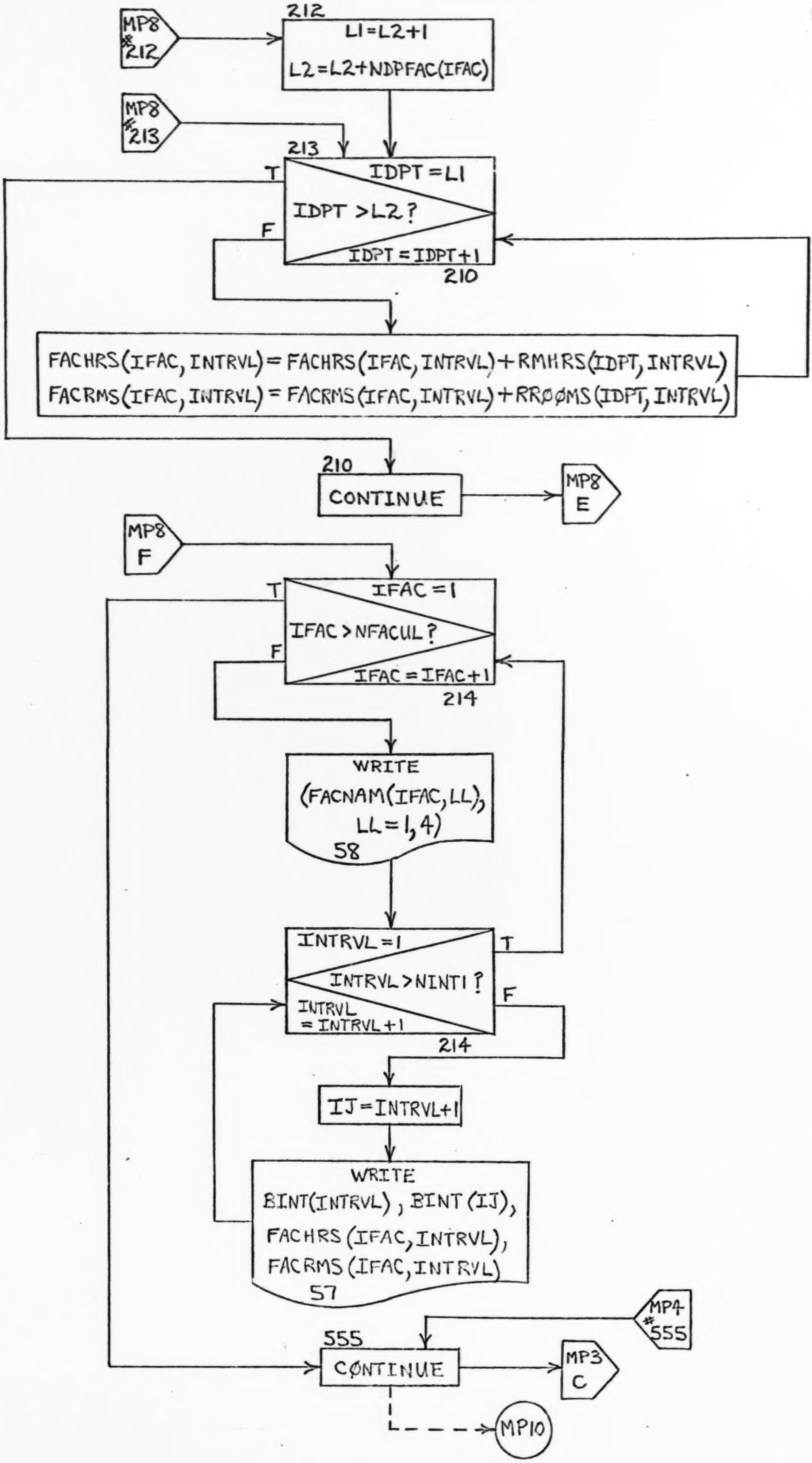

T
I=1
I>NTOTAL?
F
I=I+1
559
STØREU(I)=0.0
SIMYR>1.0?
F
T
556
IDPT=1
T
IDPT>NDP?
F
IDPT=IDPT+1
558
IYR=1
T
IYR>IACA?
F
IYR=IYR+1
558
RØLEES(IDPT,IYR)=RØLEES(IDPT,IYR)*((100.0+(SIMYR*2.0))/100.0)
557
CALL FACIL
CALL ØRCAST
CALL UWIDE
SKIP=1.0?
T
MP9 #555
F
SUTIL=SUTAL
STØPP=SSTØP
MRØUND=1
MP5

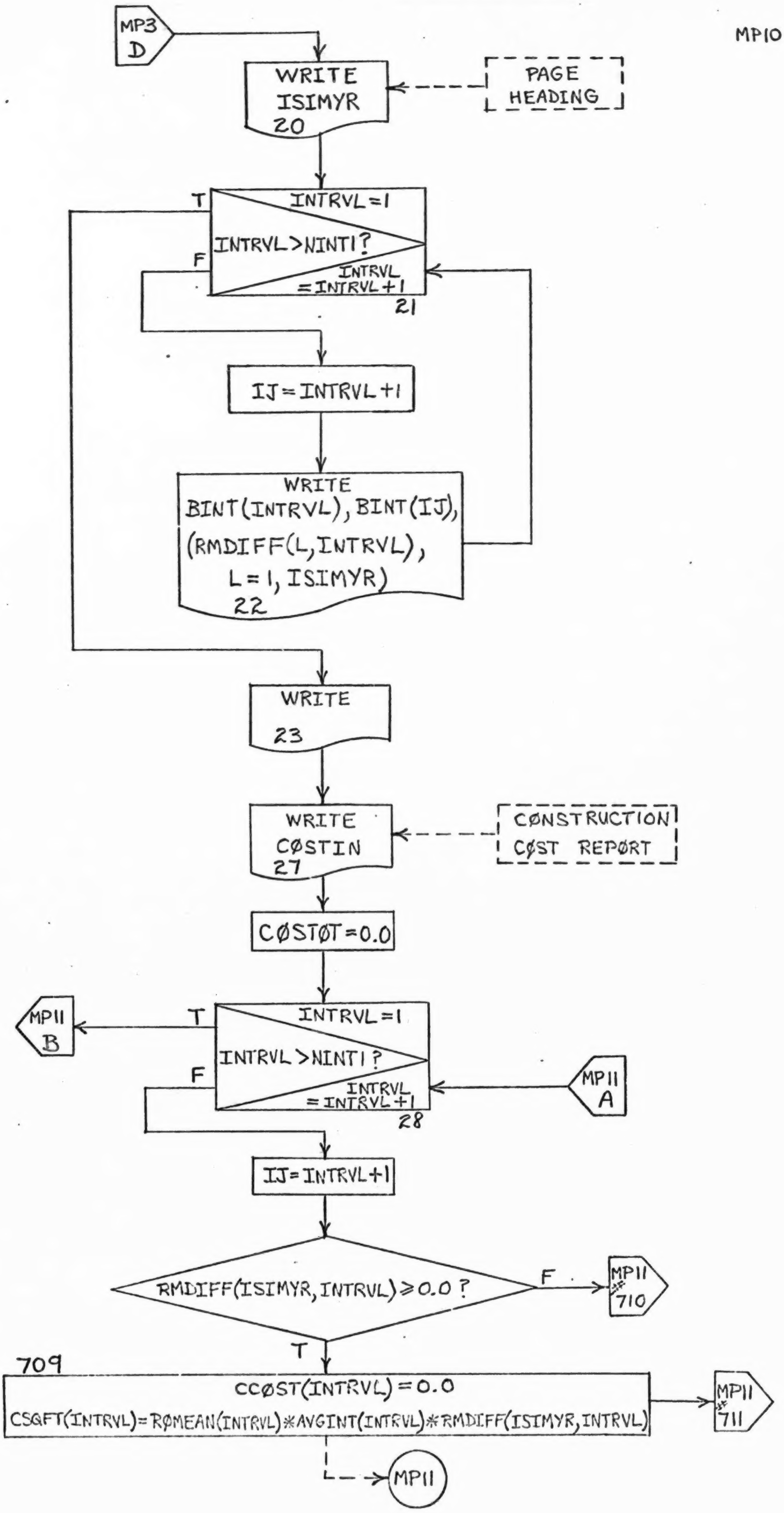

16
CALL MATCH
MP6 #16
SUMMAX(MROUND)=EFFMAT +EFFSAT +OVERSU
WRITE
SUMMAX (MROUND),
MROUND, SUTIL
588
SULØW≠100.0
AND
STØPP≠0.0 ?
F
MP6 #19
T
18
MRØUND≠1 ?
T
F
SUTIL= SUTIL -THIS
MRØUND= MRØUND +1
T
INTRVL=1
INTRVL >NINT2 ?
F
INTRVL
=INTRVL+1
24
CINT(INTRVL)=BINT(INTRVL) *(100.0/SUTIL)
15
SUMMAX(MROUND)>SUMMAX(MROUND-1)
?
T
MP6 #17
F
SUTIL = SUTIL +THIS
MP6

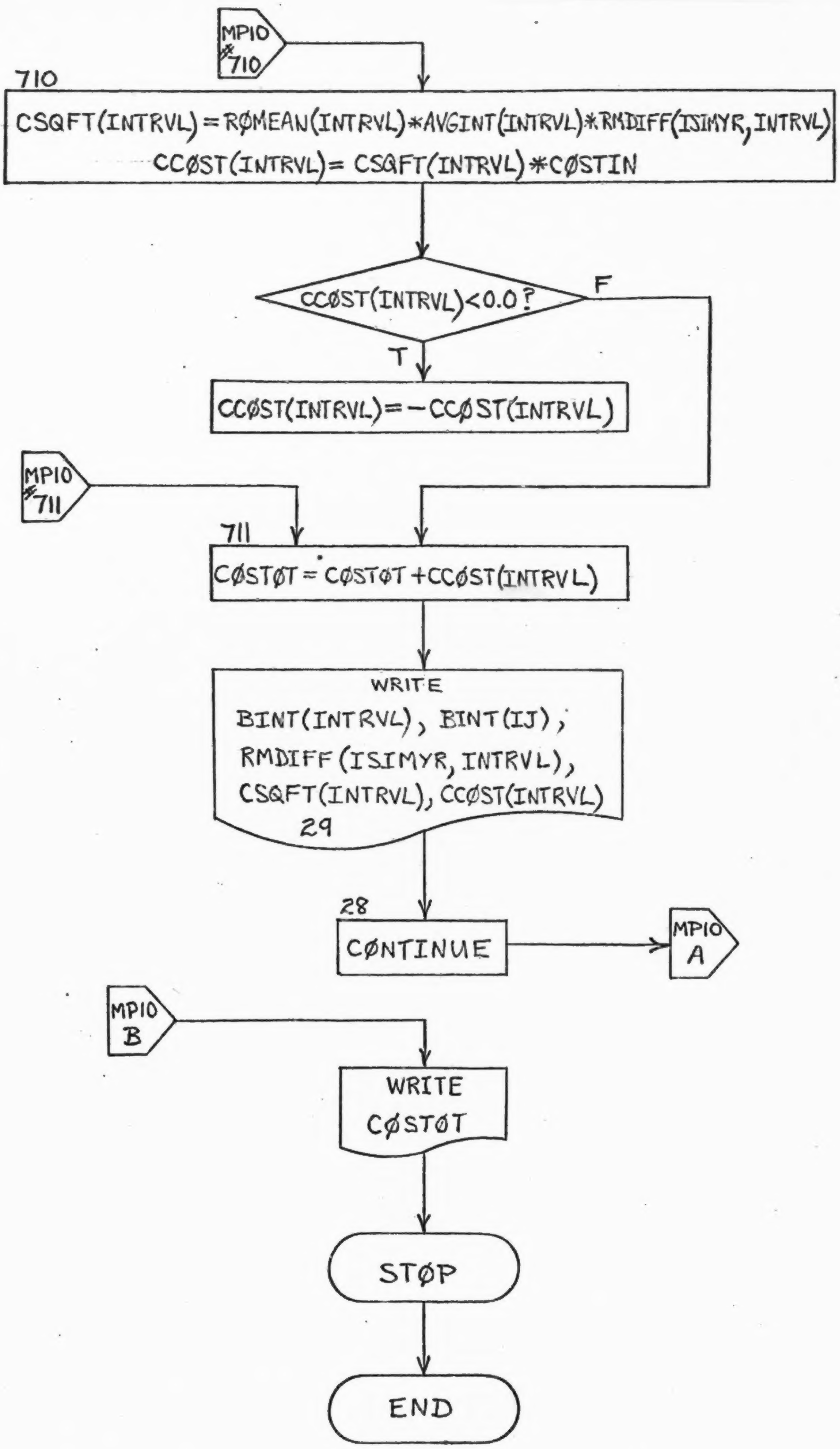

T
INTRVL=1
INTRVL>NINT2?
F
INTRVL
=INTRVL+1
25
CINT(INTRVL) = BINT(INTRVL) * (100.0/SUTIL)
MRØUND=MRØUND-1
STØPP=0.0
MP5
*16
MP5
*17
17
SUTIL ≤SULØW?
T
F
RØUND= MRØUND
SUTIL = 100.0 - RØUND *THIS
MROUND = MRØUND+1
MP5
*16
T
INTRVL=1
INTRVL>NINT2?
F
INTRVL
=INTRVL+1
26
CINT (INTRVL) = BINT (INTRVL) *(100.0/SUTIL)
MP5
*19
19
IDPT=1
MP8
D
T
IDPT>NDP?
F
IDPT=IDPT+1
9
MP8
A
WRITE
(DPNAME (IDPT, KK),
KK=1,4)
72
PAGE
HEADINGS
MP7


WRITE
73
CØLUMN HEADINGS
T
INTRVL=1
INTRVL>NINT1?
F
INTRVL =INTRVL+1
13
IJ=INTRVL+1
WRITE
BINT(INTRVL), BINT(IJ),
RMHRS(IDPT, INTRVL),
RRØØMS(IDPT, INTRVL),
REMRMS(IDPT, INTRVL)
74
WRITE
TEAWK(IDPT),
DRUTIL(IDPT),
SUTIL
75
PARAMETER VALUES
NØTFND=0
WRITE
(DPNAME(IDPT, L),
L=1, 4)
406
WRITE
407
CØLUMN HEADINGS
MP8 C
T
I=1
I>NTAG?
F
I=I+1
506
MP8 B
MP8 #506
F
LØDEPT(I)=IDPT AND LCHECK(I)=1?
T
MP8 #507
MP8


MP7
*507
507
WRITE
(BBLDG(I,K), K=1,3),
LRØØM(I), SSEATS(I),
STØREU(I)
408
NØTFND=NØTFND+1
MP7
*506
506
CØNTINUE
MP7
B
MP7
C
NØTFND=0?
F
T
508
WRITE
409
9
CØNTINUE
MP6
A
MP6
D
INTRVL=1
T
MP9
F
INTRVL>NINT1?
F
INTRVL
=INTRVL+1
210
IFAC=1
T
IFAC>NFACUL?
MP9
E
F
IFAC=IFAC+1
210
FACHRS(IFAC,INTRVL)=0.0
FACRMS(IFAC,INTRVL)=0.0
IFAC=1?
MP9
*212
T
211
L1=1
L2=NDPFAC(IFAC)
MP9
*213
MP9


MP8 #212
212
L1=L2+1
L2=L2+NDPFAC(IFAC)
MP8 #213
213
T
IDPT=L1
IDPT >L2?
F
IDPT=IDPT+1
210
FACHRS(IFAC, INTRVL) = FACHRS(IFAC, INTRVL) + RMHRS(IDPT, INTRVL)
FACRMS(IFAC, INTRVL) = FACRMS(IFAC, INTRVL) + RRØØMS(IDPT, INTRVL)
210
CONTINUE
MP8 E
MP8 F
T
IFAC=1
IFAC>NFACUL?
F
IFAC=IFAC+1
214
WRITE
(FACNAM(IFAC,LL), LL=1,4)
58
INTRVL=1
T
INTRVL>NINT1?
F
INTRVL =INTRVL+1
214
IJ=INTRVL+1
WRITE
BINT(INTRVL), BINT(IJ),
FACHRS(IFAC,INTRVL),
FACRMS(IFAC,INTRVL)
57
MP4 #555
555
CØNTINUE
MP3 C
MP10

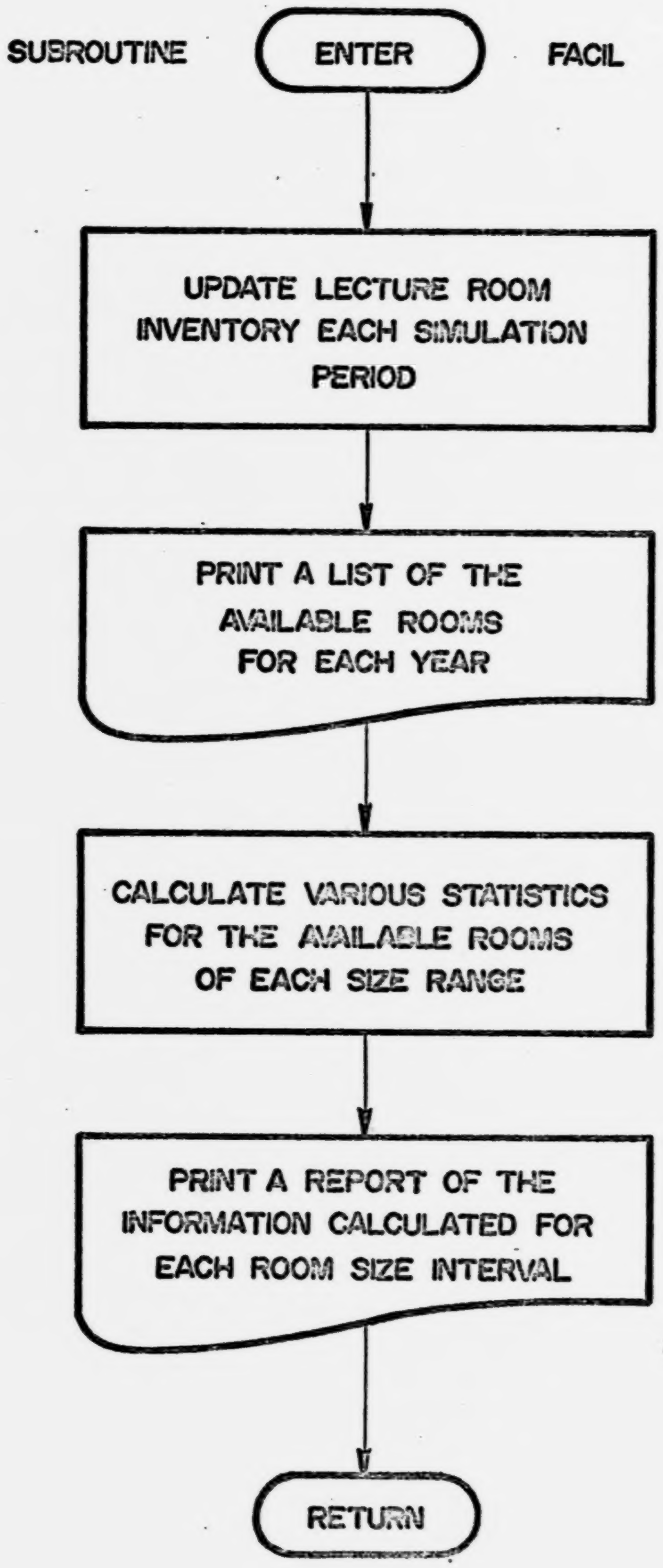

MP3 D
WRITE ISIMYR
20
PAGE HEADING
T
INTRVL=1
INTRVL>NINT1?
F
INTRVL =INTRVL+1
21
IJ=INTRVL+1
WRITE BINT(INTRVL), BINT(IJ), (RMDIFF(L,INTRVL), L=1, ISIMYR)
22
WRITE
23
WRITE CØSTIN
27
CØNSTRUCTION CØST REPØRT
CØSTØT=0.0
MP11 B
T
INTRVL=1
INTRVL>NINT1?
F
INTRVL =INTRVL+1
28
MP11 A
IJ=INTRVL+1
RMDIFF(ISIMYR,INTRVL)≥0.0?
F
MP11 * 710
T
709
CCØST(INTRVL)=0.0
CSQFT(INTRVL)=RØMEAN(INTRVL)*AVGINT(INTRVL)*RMDIFF(ISIMYR,INTRVL)
MP11 * 711
MP11

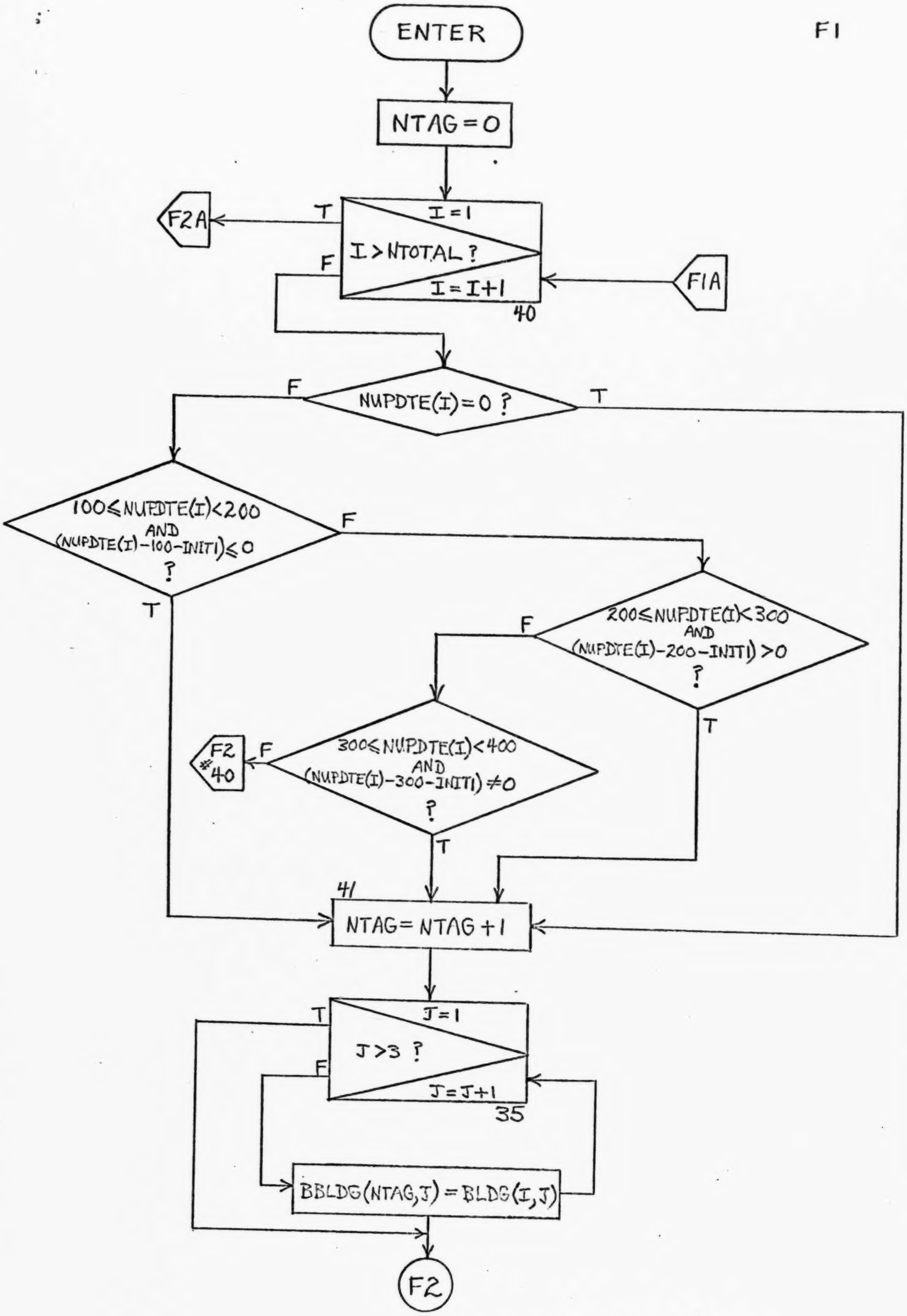

MP10 #710
710
CSQFT(INTRVL) = RØMEAN(INTRVL)*AVGINT(INTRVL)*RMDIFF(ISIMYR, INTRVL)
CCØST(INTRVL) = CSQFT(INTRVL)*CØSTIN
CCØST(INTRVL)<0.0?
F
T
CCØST(INTRVL) = −CCØST(INTRVL)
MP10 #711
711
CØSTØT = CØSTØT + CCØST(INTRVL)
WRITE
BINT(INTRVL), BINT(IJ),
RMDIFF (ISIMYR, INTRVL),
CSQFT(INTRVL), CCØST(INTRVL)
29
28
CØNTINUE
MP10 A
MP10 B
WRITE
CØSTØT
STØP
END

```
C*************************************************************************
C     MAIN PROGRAM.  READS IN DATA, CALLS IN SUBROUTINES, CALCULATES THE OPTIMUM
C     MATCHING OF LECTURE ROOM SPACE REQUIREMENTS VERSUS AVAILABILITY OF SPACE,
      PRINTS VARIOUS DEPARTMENTAL AND FACULTY SPACE REPORTS, PRINTS A SUMMARY
C     OF UNIVERSITY LECTURE ROOM SPACE REQUIREMENTS OVER THE YEARS SIMULATED,
C     AND REPORTS THE EXPECTED COST OF BUILDING FOR A SHORTAGE OF ROOMS OF EACH
C     SIZE RANGE.
C*************************************************************************
      COMMON BLDG(250,3),NBLDG(250),NROOM(250),CCOST(7),    SEATS(250),
     *NODEPT(250),NRES(250),NUPDTE(250),SQFT(250),SQPERS(250),
     *DEVIAT(250),BBLDG(250,3),LBLDG(250),LROOM(250),ROMEAN(7),
     *SSEATS(250),LODEPT(250),LRES(250),LUPDTE(250),SSQFT(250),
     *NCHECK(250),LCHECK(250),RMTOT(7),SEATOT(7),RMHRTO(7),RMHRS(100,7),
     *ITEST(100,9),ROLEES(100,9),STR(100,9),HL(100,9),ROMHRS(100,9),
     *FACHRS(20,7),AMTOFF(100),ROLEED(250,7),DIST(250,7),BINT(8),
     *FACRMS(20,7),AMIDPT(7),URMS(7),DPNAME(100,4),TRMHRS(7),NDISI,NDP,
     *IACA,NINT1,UTEAWK,SUTIL,RUTIL,NTOTAL,NTAG,INIT1,STOREU(250),
     *DRUTIL(100),TEAWK(100),ASSIGN(100)   ,BLDPRI(100,5),AVGISS(100,7),
     *REMRMS(100,7),RROOMS(100,7),SUTILZ(250),            NPRIOR,
     *RMSASN(7),DIFFHR(7),DIFFRM(7),HRUTIL(7),HRDEV(7),HRLACK(7)
     *,CINT(8),SQFTOT(7),RMTOTC(7),AVGINT(7), SIMYR,CPRMS(7),CPSEAT(7),
     *CPRMHR(7),UNSATI(7),CPDEV(7),SUSIZE(7),NDPFAC(20),NFAC(250),
     *LFAC(250),FACNAM(20,4),MATCHE(7),NOTMAT(7),PERMAT(7),NFACUL,
     *EFFMAT,EFFSAT,SUMMAX(20),PERSAT(7),RMDIFF(10,7),SKIP,SSTOP,IEND,
     *IBEGIN,COSTIN,COSTOT,ISIMYR,ROUND,MROUND,SULOW,BLDPER,CSQFT(7),
     *NINT2,OVERSU,DINT(8),RMTOTD(7),SULOWD,THIS
      REAL NRES,LRES,NBLDG,LBLDG,NROOM,LROOM
C*************************************************************************
C     THE FOLLOWING PARAMETERS MUST BE SPECIFIED AND READ.     MAXIMUM DIMENSION
C     NDP    = NUMBER OF DEPARTMENTS                                   100
C     NFACUL= NUMBER OF FACULTIES FOR WHICH SUMMARY REPORTS              3
C              ARE CALCULATED AND PRINTED
C     NDIST = NUMBER OF DEPARTMENTAL INPUT DISTRIBUTIONS               250
C     NTOTAL= TOTAL NUMBER OF UNIVERSITY LECTURE ROOMS ON CAMPUS       250
C              OR SCHEDULED FOR FUTURE CONSTRUCTION
C     NPRIOR= NUMBER OF DEPARTMENTAL BUILDING PRIORITIES                 5
C     IACA   = NUMBER OF ACADEMIC YEARS                                  9
C     NINT1 = NUMBER OF ROOM SIZE INTERVALS                              7
C     IBEGIN= THE BEGINNING SIMULATION YEAR
C     IEND   = THE FINAL SIMULATION YEAR
C     UTEAWK= AVERAGE LENGTH OF THE UNIVERSITY TEACHING WEEK            99.9
C     SUTAL = DESIRED AVERAGE UNIVERSITY SEAT UTILIZATION              100.0
C     RUTIL = AVERAGE UNIVERSITY ROOM UTILIZATION                      100.0
C     SSTOP = A PARAMATER TO CONTROL THE OPTIMIZATION ROUTINE
C              IN THE MATCHING PROCESS
C     SKIP   = A PARAMETER TO CONTROL PROGRAM OUTPUT OPTIONS
C     SULOW = THE LOWEST TOLERABLE SEAT UTILIZATION IN THE             100.0
C              MATCHING PROCESS
C     SULOWD= THE SEAT UTILIZATION TOLERATED IN THE UNIVERSITY         100.0
C              WIDE MATCHING PROCESS
C     THIS   = SEAT UTILIZATION INCREMENT IN THE OPTIMIZATION           20.0
C              ROUTINE FOR THE MATCHING PROCESS
C     COSTIN= CONSTUCTION COST INDEX $/SQ. FT.
C*************************************************************************
      READ(5,840)NDP,NFACUL,NDIST,NTOTAL,NPRIOR,IACA,NINT1,IBEGIN,IEND
  840 FORMAT(20I3)
      READ(5,401)UTEAWK,SUTAL,RUTIL,SSTOP,SKIP,SULOW,SULOWD,THIS,COSTIN
C*************************************************************************
C     READ THE FOLLOWING DATA.
C     LECTURE ROOM INVENTORY SPECIFICATIONS -
```

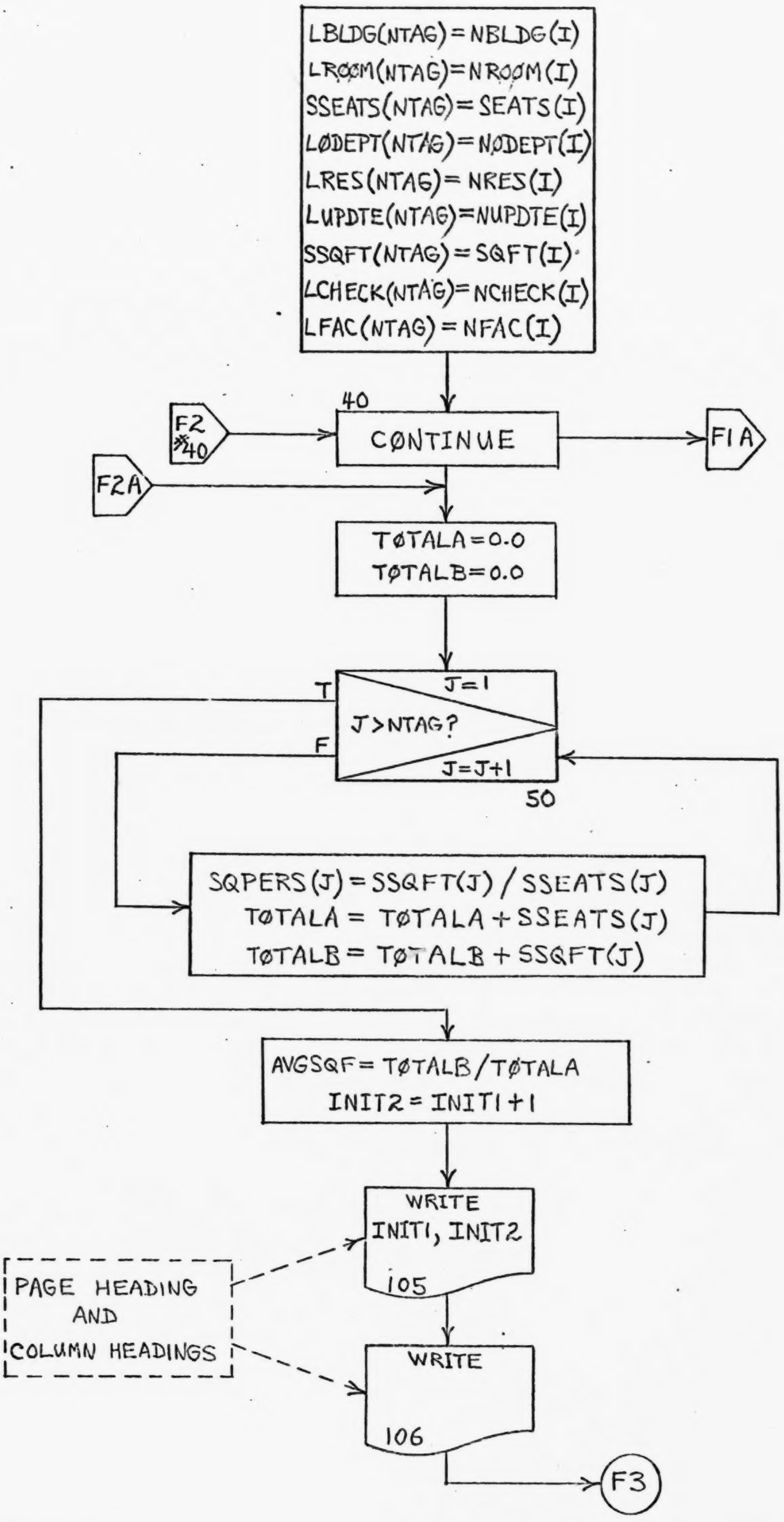
```
C              BLDG   = BUILDING NAME
C              NBLDG = BUILDING NUMBER
C              NROOM = ROOM NUMBER
               SEATS = NUMBER OF SEATS
C              NODEPT= DEPARTMENTAL AFFILIATION NUMBER
C              NRES   = NUMBER OF WEEKLY HOURS OF RESTRICTED USAGE
C              NUPDTE= UPDATING CODE
C              SQFT   = SQUARE FOOTAGE
C              NCHECK= ROOM ASSIGNMENT CHECK BIT
C              NFAC   = FACULTY AFFILIATION NUMBER
C                          ----
C      ROLEES= FORECASTED DEPARTMENTAL ENROLLMENT
C      STR    = FORECASTED SECTION SIZES
C      HL     = FORECASTED HOURS/WEEK/SECTION
C      AMIDPT= SIZE INTERVAL MIDPOINTS
C      BINT   = SIZE INTERVAL END POINTS
C      DIST   = DEPARTMENTAL ENROLLMENT SIZE RANGE DISTRIBUTION
C      DPNAME= DEPARTMENT NAMES
C      DRUTIL= DEPARTMENTAL ROOM UTILIZATION PERCENTAGE
C      TEAWK = DEPARTMENTAL TEACHING WEEK LENGTH (HOURS)
C      AMTOFF= PERCENTAGE OF DEPARTMENTAL SEMINARS HELD IN PROFESSORS- OFFICES
C      ASSIGN= DEPARTMENTAL ROOM ASSIGNMENT PARAMETER
C      BLDPRI= DEPARTMENTAL LIST OF BUILDING PRIORITIES
C      AVGISS= DEPARTMENTAL AVERAGE INTERVAL SECTION SIZE
C      FACNAM= FACULTY NAMES
C      NDPFAC= NUMBER OF DEPARTMENTS IN A FACULTY
C*******************************************************************************
      READ(5,100)((BLDG(I,J),J=1,3),NBLDG(I),NROOM(I),            SEATS(I),
     *NODEPT(I),NRES(I),NUPDTE(I),SQFT(I),NCHECK(I),NFAC(I),
     *I=1,NTOTAL)
  100 FORMAT(3A6,A4,A6,F5.0,I3,F2.0,I3,F6.0,2X,I1,I2)
      DO 10 IDPT=1,NDP
      DO 10 IYR=1,IACA
      READ(5,70)  ROLEES(IDPT,IYR),STR(IDPT,IYR),HL(IDPT,IYR),
     *ITEST(IDPT,IYR)
   10 CONTINUE
   70 FORMAT(F6.1,F5.1,F4.1,I1)
      READ(5,71)(AMIDPT(INTRVL),INTRVL=1,NINT1)
   71 FORMAT(11F5.1)
      NINT2=NINT1+1
      READ(5,71)(BINT(INTRVL),INTRVL=1,NINT2)
C*******************************************************************************
C     CALCULATE CINT - THE SIZE INTERVAL END POINTS USED IN THE DEPARTMENTAL
C     MATCHING PROCESS, AND DINT - THE ADJUSTED SIZE INTERVALS USED IN THE
C     UNIVERSITY WIDE MATCHING PROCESS.
C*******************************************************************************
      DO 61 INTRVL=1,NINT2
      CINT(INTRVL)=BINT(INTRVL)*(100.0/SUTAL)
      DINT(INTRVL)=BINT(INTRVL)*(100.0/SULOWD)
   61 CONTINUE
      DO 63 LABEL=1,NDIST
      READ(5,71)(DIST(LABEL,INTRVL),INTRVL=1,NINT1)
   63 CONTINUE
      READ(5,69)((DPNAME(IDPT,L),L=1,4),IDPT=1,NDP)
   69 FORMAT(4A6)
      READ(5,401)(DRUTIL(IDPT),IDPT=1,NDP)
      READ(5,401)(TEAWK(IDPT),IDPT=1,NDP)
      READ(5,401)(AMTOFF(IDPT),IDPT=1,NDP)
      READ(5,401)(ASSIGN(IDPT),IDPT=1,NDP)
  401 FORMAT(16F5.1)
      DO 302 IDPT=1,NDP
      READ(5,404)(BLDPRI(IDPT,IPRIOR),IPRIOR=1,NPRIOR)
  404 FORMAT(5A4)
  302 CONTINUE
      DO 303 IDPT=1,NDP
      READ(5,400)(AVGISS(IDPT,INTRVL),INTRVL=1,NINT1)
  400 FORMAT(7F5.1)
  303 CONTINUE
      READ(5,69)((FACNAM(IFAC,L),L=1,4),IFAC=1,NFACUL)
      READ(5,59)(NDPFAC(IFAC),IFAC=1,NFACUL)
   59 FORMAT(20I2)
C*******************************************************************************
C     THIS DO LOOP CONTROLS THE SIMULATION MODEL THROUGH EACH YEAR FROM IBEGIN
C     TO IEND.  SIMYR = THE NUMBER OF YEARS SIMULATED.
C*******************************************************************************
      SIMYR=0.0
      DO 555 INIT1=IBEGIN,IEND
      SIMYR=SIMYR+1.0
      ISIMYR=SIMYR
      DO 559 I=1,NTOTAL
      STOREU(I)=0.0
  559 CONTINUE
      IF(SIMYR.GT.1.0) GO TO 556
      GO TO 557
C*******************************************************************************
C     SINCE ENROLLMENT FORECASTS FOR THE NEXT TEN YEARS ARE STILL BEING
C     PREPARED BY THE OFFICE OF INSTITUTIONAL RESEARCH, TEMPORARILY A 2.0
C     PERCENT INCREASE IN THE ENROLEES TOTAL FOR EACH ACADEMIC YEAR OF EACH
C     DEPARTMENT IS ASSUMED FOR MODEL TESTING PURPOSES.
C*******************************************************************************
  556 DO 558 IDPT=1,NDP
      DO 558 IYR=1,IACA
      ROLEES(IDPT,IYR)=ROLEES(IDPT,IYR)*((100.0+(SIMYR* 2.0))/100.0)
  558 CONTINUE
  557 CALL FACIL
      CALL ORCAST
      CALL UWIDE
C*******************************************************************************
C     IF SKIP = 1.0, SUBROUTINES MATCH AND SEARCH ARE NOT CALLED. THIS ENABLES
C     THE RESULTS OF SUBROUTINES FACIL, ORCAST, AND UWIDE TO BE EXAMINED FOR
C     MANY SIMULATION YEARS WHILE AVOIDING THE TIME AND OUTPUT RQUIREMENTS OF
C     MATCH AND SEARCH.
C     IF SKIP = 0.0, THE COMPLETE PROGRAM IS RUN.
C*******************************************************************************
      IF(SKIP.EQ.1.0) GO TO 555
C*******************************************************************************
C     THE FOLLOWING STATEMENTS CAUSE SUBROUTINE MATCH TO BE CALLED REPEATEDLY
C     WITH DIFFERENT VALUES OF SEAT UTILIZATION(SUTIL). THE PROGRAM MAXIMIZES
C     THE SUM SUMMAX. THE STARTING SEAT UTILIZATION IS SUTAL. THE PROGRAM THEN
C     CALLS MATCH FOR SUCCESSIVE VALUES OF SUTIL, EACH TIME SUTIL BEING
C     DECREASED BY AN AMOUNT THIS. ONCE AN OPTIMUM VALUE IS FOUND FOR SUMMAX,
C     THE PROGRAM EXITS TO PRINT DEPARTMENTAL MATCHING REPORTS.
C     SUMMAX IS A SUM OF EFFSAT+EFFMAT+OVERSU WHICH ARE CALCULATED AND DEFINED
C     IN SUBROUTINE MATCH.
C     MROUND= THE MATCHING ITERATION NUMBER.
C*******************************************************************************
      SUTIL=SUTAL
      STOPP=SSTOP
      MROUND=1
   16 CALL MATCH
      SUMMAX(MROUND)=EFFSAT+EFFMAT+OVERSU
      WRITE(6,588)SUMMAX(MROUND),MROUND,SUTIL
  588 FORMAT(1H1,7HSUMMAX=F6.1,5X,15HMATCHING NUMBERI2,5X,
     *18HSEAT UTILIZATION =F6.1)
C***********************************************************************
C     TO SUPRESS THE OPTIMIZATION ROUTINE SPECIFY SSTOP = 0.0 . ONE PARTICULAR
C     VALUE OF SEAT UTILIZATION(SUTAL) MAY BE INSERTED IN THE MATCHING PROCESS.
C     DEPARMENTAL MATCHING REPORTS ARE THEN PRINTED FOR THIS VALUE SUTAL.
C***********************************************************************
      IF(SULOW.NE.100.0.AND.STOPP.NE.0.0) GO TO 18
      GO TO 19
   18 IF(MROUND.NE.1) GO TO 15
      SUTIL=SUTIL-THIS
      MROUND=MROUND+1
      DO 24 INTRVL=1,NINT2
      CINT(INTRVL)=BINT(INTRVL)*(100.0/SUTIL)
   24 CONTINUE
      GO TO 16
   15 IF(SUMMAX(MROUND).GT.SUMMAX(MROUND-1)) GO TO 17
      SUTIL=SUTIL+THIS
      DO 25 INTRVL=1,NINT2
      CINT(INTRVL)=BINT(INTRVL)*(100.0/SUTIL)
   25 CONTINUE
      MROUND=MROUND-1
      STOPP=0.0
      GO TO 16
   17 IF(SUTIL.LE.SULOW) GO TO 19
      ROUND=MROUND
      SUTIL=100.0-ROUND*THIS
      MROUND=MROUND+1
      DO 26 INTRVL=1,NINT2
      CINT(INTRVL)=BINT(INTRVL)*(100.0/SUTIL)
   26 CONTINUE
      GO TO 16
C***********************************************************************
C     PRINT DEPARTMENTAL FORECASTED SPACE REQUIREMENTS REPORTS AND SPACE
C     MATCHING REPORTS.
C***********************************************************************
   19 DO 9 IDPT=1,NDP
      WRITE(6,72)(DPNAME(IDPT,KK),KK=1,4)
   72 FORMAT(1H1/103X,13HREPORT PAGE 1/47X,23HUNIVERSITY  OF  TORONTO//
     *37X,44HC.A.M.P.U.S.  SIMULATION  PLANNING  ANALYSIS///43X,
     *4A6,7H REPORT/43X,31H--------------------           //45X,
     *29HFORECASTED SPACE REQUIREMENTS//)
      WRITE(6,73)
   73 FORMAT(30X,58HLECTURE ROOM DISTRIBUTION IN ROOM-HOURS BY ROOM SIZE
     * RANGE//10X,14HSIZE(STUDENTS),10X,16HROOM-HOURS REQD.,10X,
     *12HNO. OF ROOMS,8X,36HUNSATISFIED ROOM REQ. AFTER MATCHING//)
      DO 13 INTRVL=1,NINT1
      IJ=INTRVL+1
      WRITE(6,74)BINT(INTRVL),BINT(IJ),RMHRS(IDPT,INTRVL),RROOMS(IDPT,
     *INTRVL),REMRMS(IDPT,INTRVL)
   74 FORMAT(10X,F5.0,4H TO ,F5.0,14X,F6.1,18X,F6.2,26X,F6.2)
   13 CONTINUE
      WRITE(6,75)TEAWK(IDPT),DRUTIL(IDPT),SUTIL
   75 FORMAT(//1X,51HNUMBER OF ROOMS CALCULATED USING A TEACHING WEEK OF
     *F6.1,6H HOURS/1X,33HROOM UTILIZATION PARAMETER SET ATF6.1,
     *8H PERCENT/1X,33HSEAT UTILIZATION PARAMETER SET ATF6.1,8H PERCENT)
      NOTFND=0
      WRITE(6,406)(DPNAME(IDPT,L),L=1,4)
  406 FORMAT(1H0,4X,70HTHE FOLLOWING ROOMS ARE AVAILABLE TO SATISFY THE
     *ROOM REQUIREMENTS FOR 4A6//)
      WRITE(6,407)
  407 FORMAT(23X,13HBUILDING NAME,3X,11HROOM NUMBER,3X,13HROOM CAPACITY,
     *3X,16HSEAT UTILIZATION/23X,13H-------------,3X,11H-----------,
     *3X,13H-------------,3X,16H----------------)
      DO 506 I=1,NTAG
      IF(LODEPT(I).EQ.IDPT.AND.LCHECK(I).EQ.1) GO TO 507
      GO TO 506
  507 WRITE(6,408)(BBLDG(I,K),K=1,3),LROOM(I),SSEATS(I),STOREU(I)
  408 FORMAT(1H0,20X,3A6,3X,A6,9X,F5.0,12X,F6.1)
      NOTFND=NOTFND+1
  506 CONTINUE
      IF(NOTFND.EQ.0) GO TO 508
      GO TO 9
  508 WRITE(6,409)
  409 FORMAT(1H0,121HNO SUITABLE ROOMS WERE FOUND TO SATISFY THE ROOM RE
     *QUIREMENTS.  SCHEDULE REQUIREMENTS FROM ROOMS IN THE CENTRAL ROOM
     *POOL//)
    9 CONTINUE
C***********************************************************************
C     PRINT FACULTY SUMMARY REPORTS OF FORECASTED SPACE REQUIREMENTS.
C***********************************************************************
      DO 210 INTRVL=1,NINT1
      DO 210 IFAC=1,NFACUL
      FACHRS(IFAC,INTRVL)=0.0
      FACRMS(IFAC,INTRVL)=0.0
      IF(IFAC.EQ.1) GO TO 211
      GO TO 212
  211 L1=1
      L2=NDPFAC(IFAC)
      GO TO 213
  212 L1=L2+1
      L2=L2+ NDPFAC(IFAC)
  213 DO 210 IDPT=L1,L2
      FACHRS(IFAC,INTRVL)=FACHRS(IFAC,INTRVL)+RMHRS(IDPT,INTRVL)
      FACRMS(IFAC,INTRVL)=FACRMS(IFAC,INTRVL)+RROOMS(IDPT,INTRVL)
  210 CONTINUE
      DO 214 IFAC=1,NFACUL
      WRITE(6,58)(FACNAM(IFAC,LL),LL=1,4)
   58 FORMAT(1H1,47X,23HUNIVERSITY  OF  TORONTO//,37X,44HC.A.M.P.U.S.  S
     *IMULATION  PLANNING  ANALYSIS///,42X,12HSUMMARY FOR ,4A6,//45X,
     *29HFORECASTED SPACE REQUIREMENTS/45X,29H--------- -
     *---//30X,58HLECTURE ROOM DISTRIBUTION IN ROOM-HOURS BY ROOM SIZE R
     *ANGE//25X,14HSIZE(STUDENTS),10X,16HROOM-HOURS REQD.,10X,
     *12HNO. OF ROOMS//)
      DO 214 INTRVL=1,NINT1
      IJ=INTRVL+1
      WRITE(6,57)BINT(INTRVL),BINT(IJ),FACHRS(IFAC,INTRVL),
     *FACRMS(IFAC,INTRVL)
   57 FORMAT(25X,F5.0,4H TO ,F5.0,14X,F7.1,19X,F5.1)
  214 CONTINUE
  555 CONTINUE
C***********************************************************************
C     AFTER A SIMULATION PERIOD OF ISIMYR YEARS, PRINT A SUMMARY OF THE
C     CHANGING LECTURE ROOM SPACE REQUIREMENTS IN EACH SIZE RANGE.
```

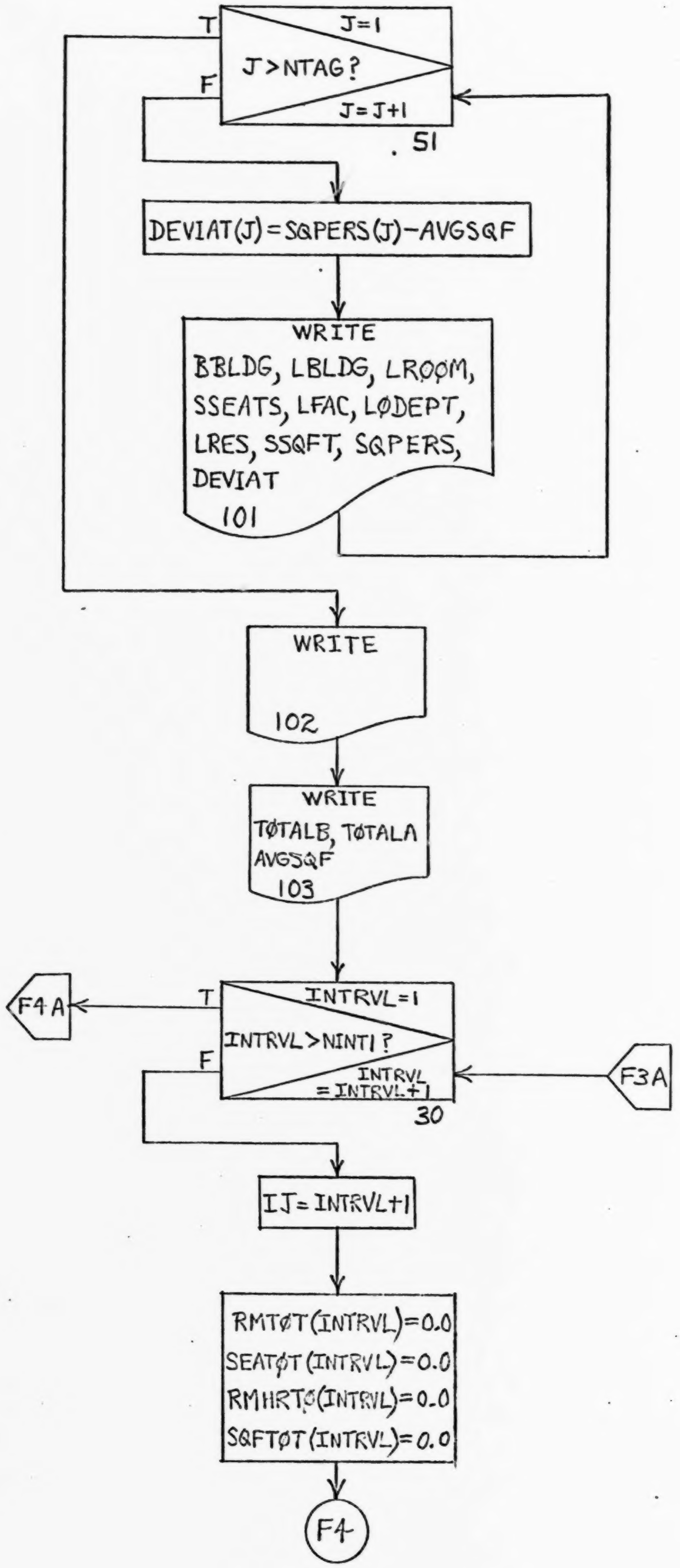
```
C*****************************************************************************
      WRITE(6,20)ISIMYR
   20 FORMAT(1H1/47X,23HUNIVERSITY  OF  TORONTO//37X,44HC.A.M.P.U.S.  SI
     *MULATION  PLANNING  ANALYSIS///,30X,59HUNIVERSITY WIDE MATCHING RE
     *PORT FOR LECTURE ROOM FACILITIES/,30X,59H=========================
     *==================================//,25X,49HSUMMARY OF ACTUAL EXCE
     *SS OR SHORTAGE OF ROOMS FORI3,17H SIMULATION YEARS/25X,69H--------
     *----------- -    -                                          //1X,
     *114HSIZE(STUDENTS)   1966-67   1967-68   1968-69   1969-70   1970-
     *71   1971-72   1972-73   1973-74   1974-75   1975-76//)
      DO 21 INTRVL=1,NINT1
      IJ=INTRVL+1
      WRITE(6,22)BINT(INTRVL),BINT(IJ),(RMDIFF(L,INTRVL),L=1,ISIMYR)
   22 FORMAT(1X,F5.0,4H TO ,F5.0,10(3X,F6.1,1X))
   21 CONTINUE
      WRITE(6,23)
   23 FORMAT(1H0,106HCHANGING PATTERN OF ROOM SHORTAGES INDICATES WHEN R
     *OOMS SHOULD BE BUILT, AND THE NUMBER AND SIZES OF ROOMS///)
C*****************************************************************************
C     PRINT A REPORT OF THE ESTIMATED CONSTRUCTION COST FOR LECTURE ROOM
C     FACILITIES OF EACH SIZE.
C*****************************************************************************
      WRITE(6,27)COSTIN
   27 FORMAT(32X,55HESTIMATED CONSTRUCTION COST FOR LECTURE ROOM FACILIT
     *IES/32X,55H---------                    -
     */39X,27HCONSTRUCTION COST INDEX = $F6.2,8H/SQ. FT.//26X,
     *14HSIZE(STUDENTS),
     *5X,17HROOM REQUIREMENTS,5X,14HSQUARE FOOTAGF,8X,4HCOST//)
      COSTOT=0.0
      DO 28 INTRVL=1,NINT1
      IJ=INTRVL+1
      IF(RMDIFF(ISIMYR,INTRVL).GE.0.0)GO TO 709
      GO TO 710
  709 CCOST(INTRVL)=0.0
      CSQFT(INTRVL)=ROMEAN(INTRVL)*AVGINT(INTRVL)*RMDIFF(ISIMYR,INTRVL)
      GO TO 711
  710 CSQFT(INTRVL)=ROMEAN(INTRVL)*AVGINT(INTRVL)*RMDIFF(ISIMYR,INTRVL)
      CCOST(INTRVL)=CSQFT(INTRVL)*COSTIN
      IF(CCOST(INTRVL).LT.0.0) CCOST(INTRVL)=-CCOST(INTRVL)
  711 COSTOT=COSTOT+CCOST(INTRVL)
      WRITE(6,29)BINT(INTRVL),BINT(IJ),RMDIFF(ISIMYR,INTRVL),
     *CSQFT(INTRVL),CCOST(INTRVL)
   29 FORMAT(26X,F5.0,4H TO ,F5.0,10X,F6.1,13X,F9.1,7X,1H$,F11.2)
   28 CONTINUE
      WRITE(6,701)COSTOT
  701 FORMAT(84X,13H-------------/84X,1H$,F12.2/,1H1)
      STOP
      END

   344*CARDS
```

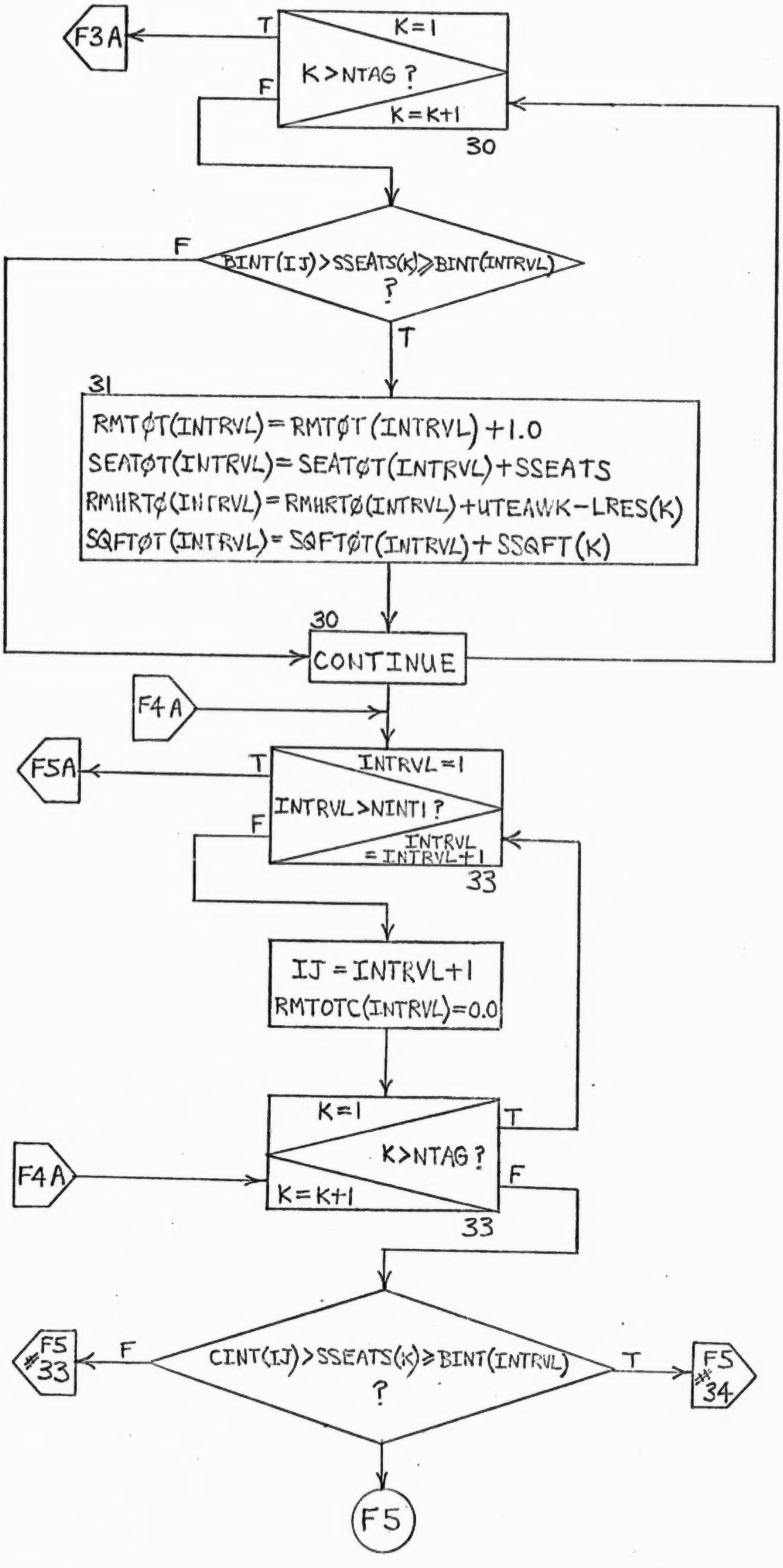

SUBROUTINE
ENTER
FACIL
UPDATE LECTURE ROOM INVENTORY EACH SIMULATION PERIOD
PRINT A LIST OF THE AVAILABLE ROOMS FOR EACH YEAR
CALCULATE VARIOUS STATISTICS FOR THE AVAILABLE ROOMS OF EACH SIZE RANGE
PRINT A REPORT OF THE INFORMATION CALCULATED FOR EACH ROOM SIZE INTERVAL
RETURN

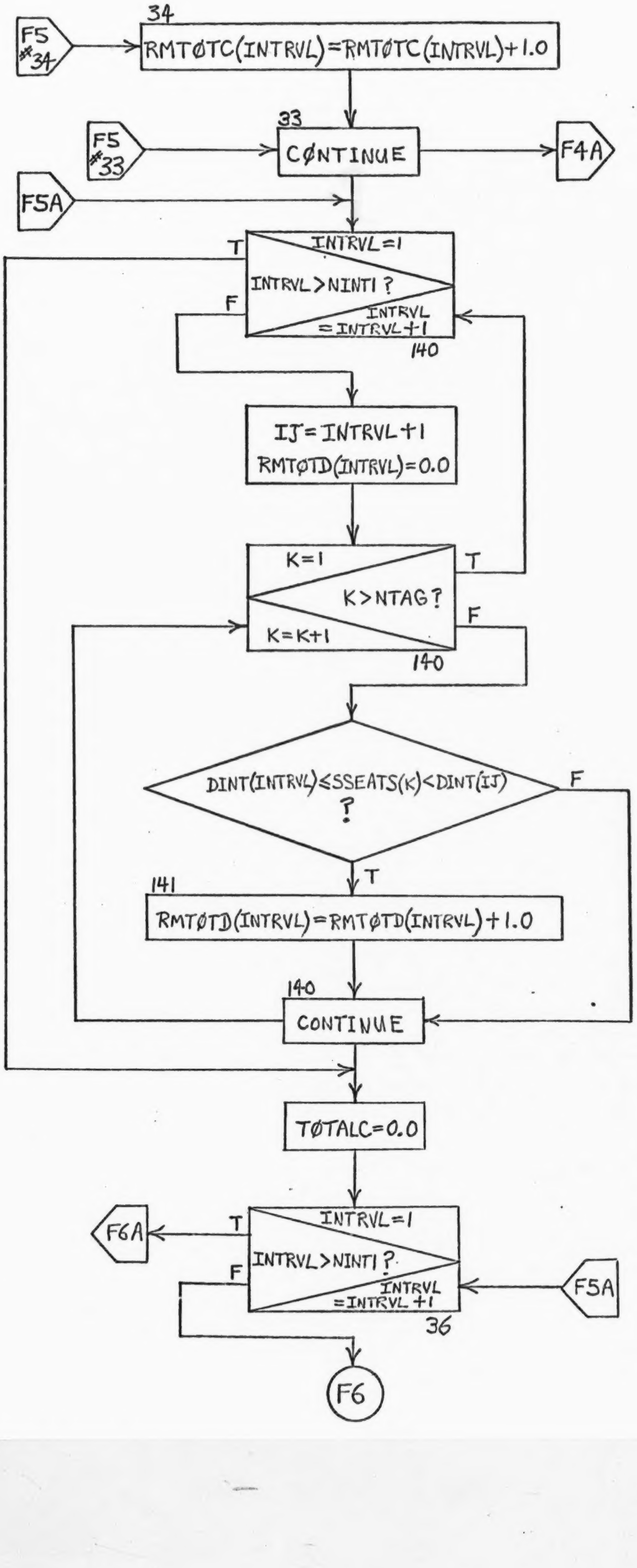

ENTER
NTAG=0
F2A
T
I=1
I>NTOTAL ?
F
I=I+1
40
F1A
F
NUPDTE(I)=0 ?
T
100≤NUPDTE(I)<200
AND
(NUPDTE(I)-100-INITI)≤0
?
F
T
200≤NUPDTE(I)<300
AND
(NUPDTE(I)-200-INITI)>0
?
F
T
F2
#40
F
300≤NUPDTE(I)<400
AND
(NUPDTE(I)-300-INITI)≠0
?
T
41
NTAG=NTAG+1
T
J=1
J>3 ?
F
J=J+1
35
BBLDG(NTAG,J)=BLDG(I,J)
F2

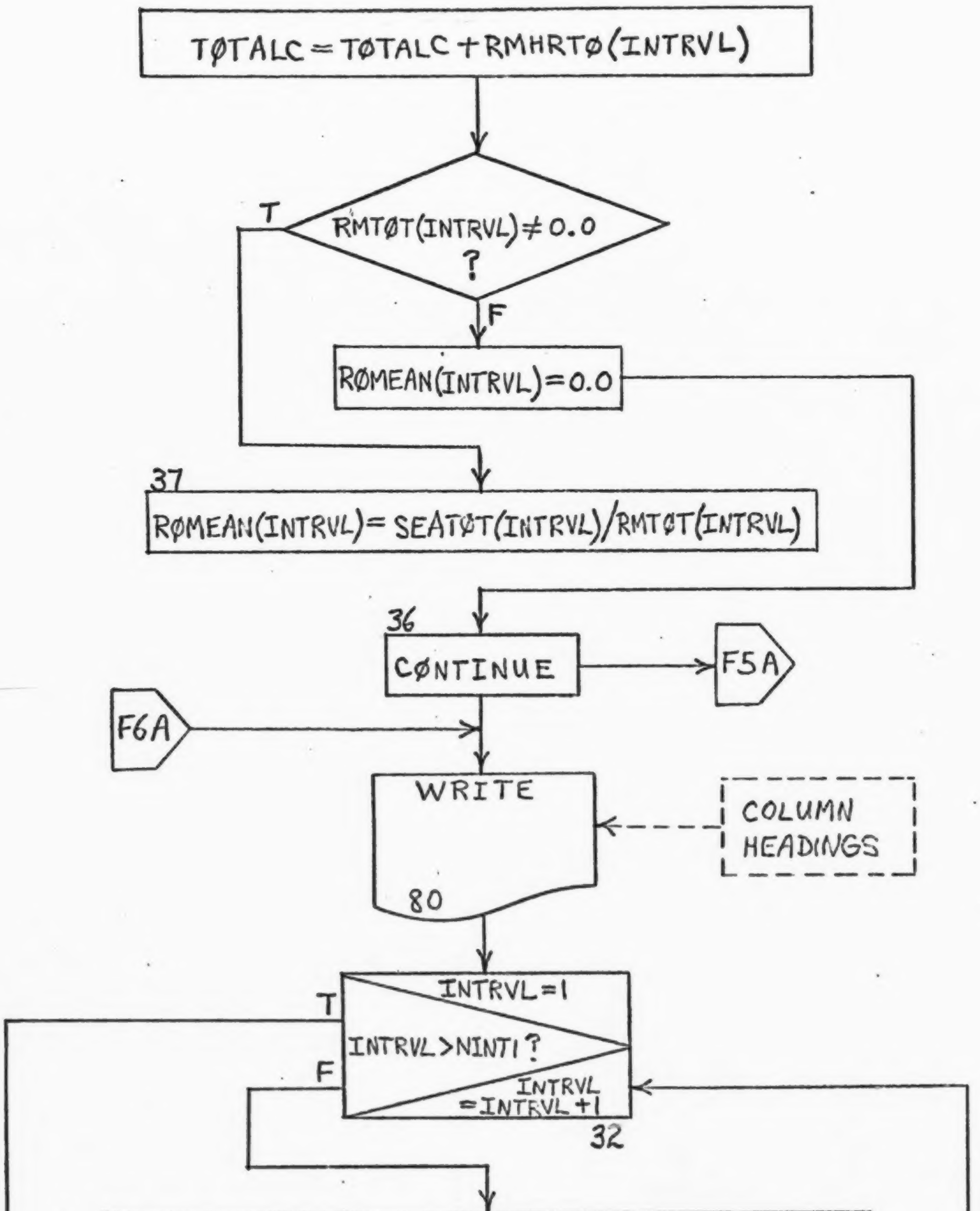
F2


LBLDG(NTAG) = NBLDG(I)
LROOM(NTAG) = NROOM(I)
SSEATS(NTAG) = SEATS(I)
LODEPT(NTAG) = NODEPT(I)
LRES(NTAG) = NRES(I)
LUPDTE(NTAG) = NUPDTE(I)
SSQFT(NTAG) = SQFT(I)
LCHECK(NTAG) = NCHECK(I)
LFAC(NTAG) = NFAC(I)
40
F2 #40
CONTINUE
F1A
F2A
TOTALA = 0.0
TOTALB = 0.0
T
J = 1
J > NTAG?
F
J = J + 1
50
SQPERS(J) = SSQFT(J) / SSEATS(J)
TOTALA = TOTALA + SSEATS(J)
TOTALB = TOTALB + SSQFT(J)
AVGSQF = TOTALB / TOTALA
INIT2 = INIT1 + 1
WRITE
INIT1, INIT2
105
PAGE HEADING
AND
COLUMN HEADINGS
WRITE
106
F3

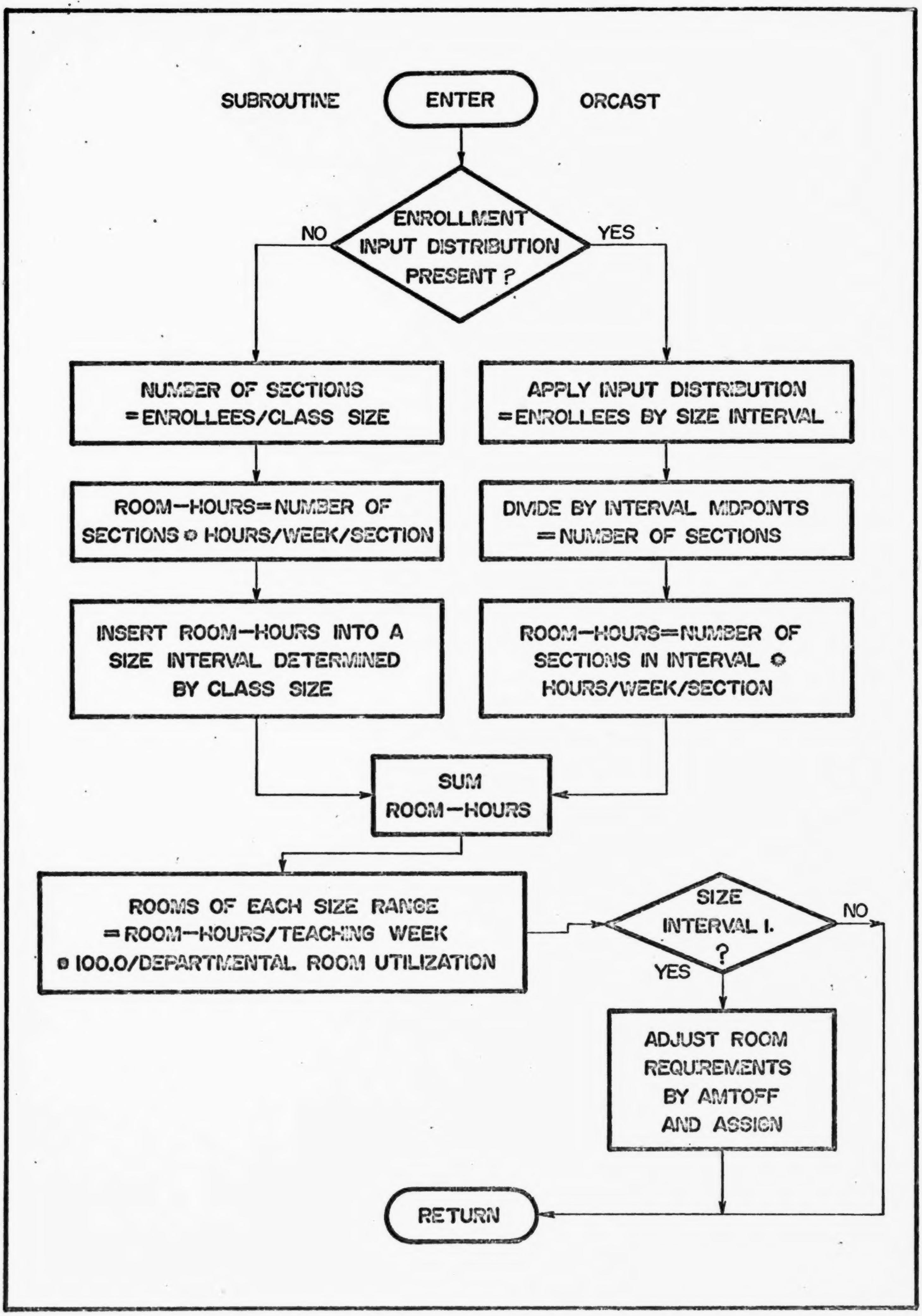

T
J=1
J>NTAG?
F
J=J+1
51
DEVIAT(J)=SQPERS(J)-AVGSQF
WRITE
BBLDG, LBLDG, LROOM,
SSEATS, LFAC, LODEPT,
LRES, SSQFT, SQPERS,
DEVIAT
101
WRITE
102
WRITE
TOTALB, TOTALA
AVGSQF
103
F4A
T
INTRVL=1
INTRVL>NINT1?
F
INTRVL
=INTRVL+1
30
F3A
IJ=INTRVL+1
RMTOT(INTRVL)=0.0
SEATOT(INTRVL)=0.0
RMHRTO(INTRVL)=0.0
SQFTOT(INTRVL)=0.0
F4

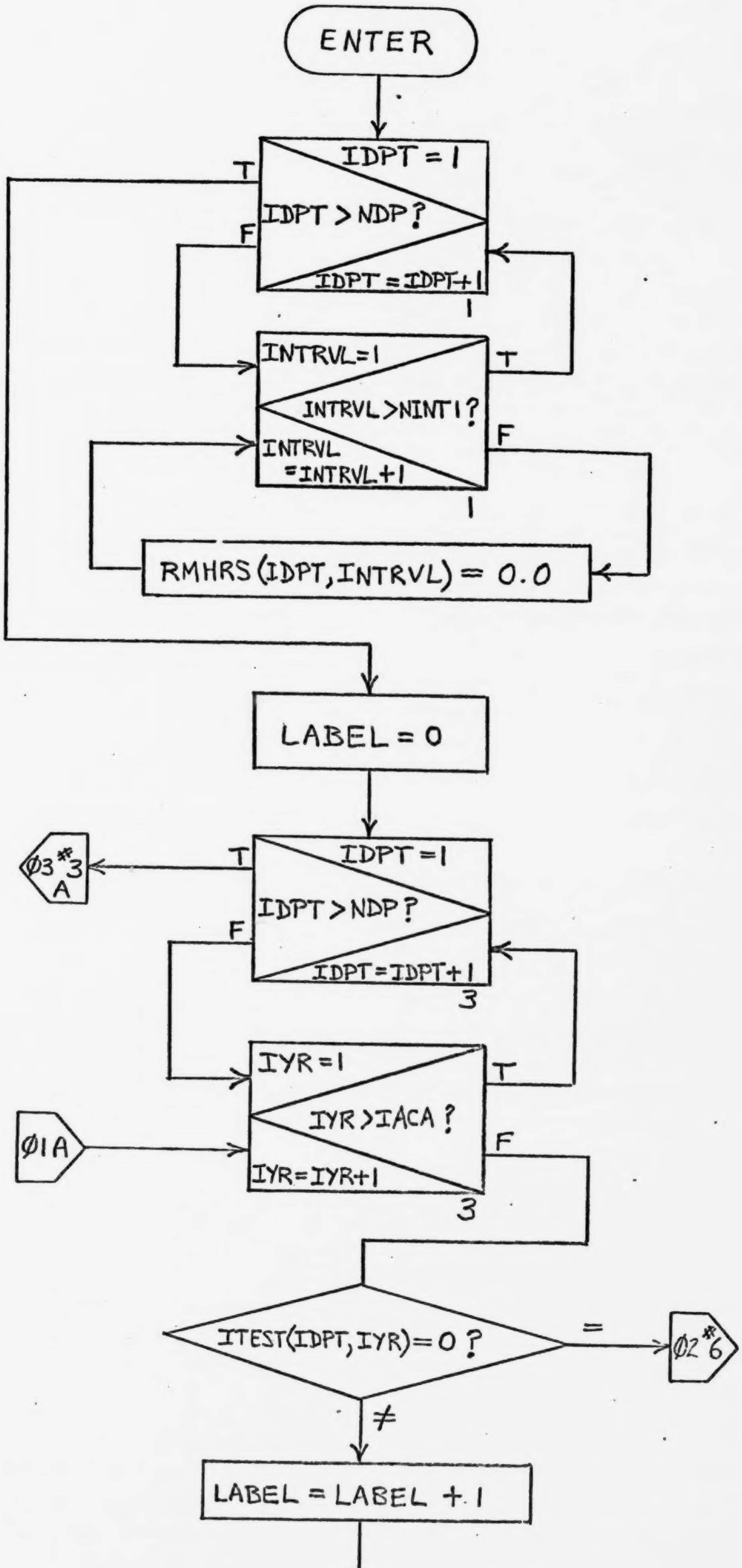

F3A
T
K=1
K>NTAG ?
F
K=K+1
30
F
BINT(IJ)>SSEATS(K)≥BINT(INTRVL)
?
T
31
RMTØT(INTRVL)=RMTØT(INTRVL)+1.0
SEATØT(INTRVL)=SEATØT(INTRVL)+SSEATS
RMHRTØ(INTRVL)=RMHRTØ(INTRVL)+UTEAWK-LRES(K)
SQFTØT(INTRVL)=SQFTØT(INTRVL)+SSQFT(K)
30
CONTINUE
F4 A
F5A
T
INTRVL=1
INTRVL>NINT1 ?
F
INTRVL
=INTRVL+1
33
IJ=INTRVL+1
RMTOTC(INTRVL)=0.0
K=1
T
K>NTAG?
F4A
F
K=K+1
33
F5
#33
F
CINT(IJ)>SSEATS(K)≥BINT(INTRVL)
?
T
F5
#34
F5

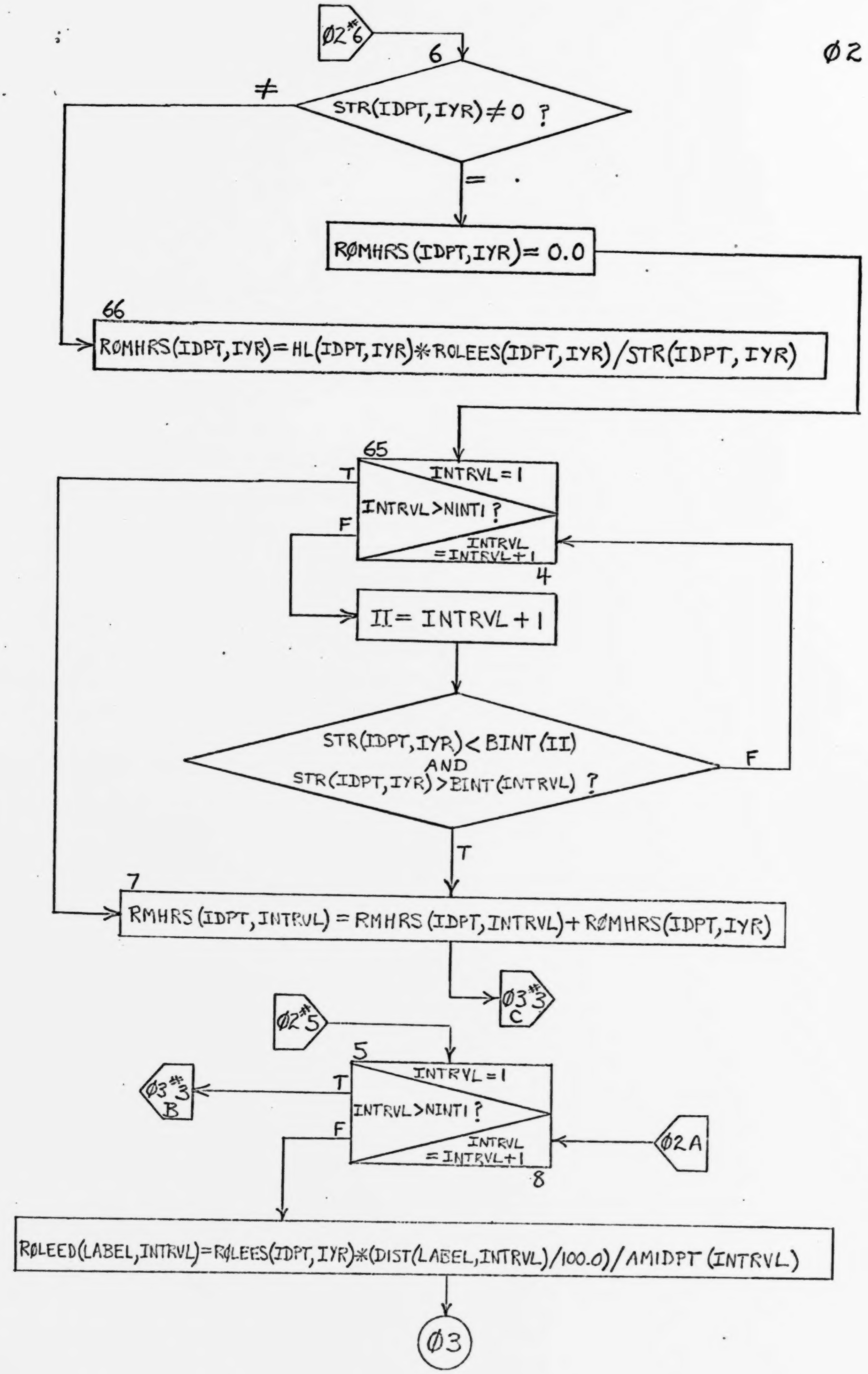

34
F5 #34
RMTOTC(INTRVL)=RMTOTC(INTRVL)+1.0
33
F5 #33
CONTINUE
F4A
F5A
T
INTRVL=1
INTRVL>NINTI ?
F
INTRVL =INTRVL+1
140
IJ=INTRVL+1
RMTOTD(INTRVL)=0.0
K=1
T
K>NTAG?
F
K=K+1
140
DINT(INTRVL)≤SSEATS(K)<DINT(IJ) ?
F
T
141
RMTOTD(INTRVL)=RMTOTD(INTRVL)+1.0
140
CONTINUE
TOTALC=0.0
F6A
T
INTRVL=1
INTRVL>NINTI ?
F
INTRVL =INTRVL+1
F5A
36
F6

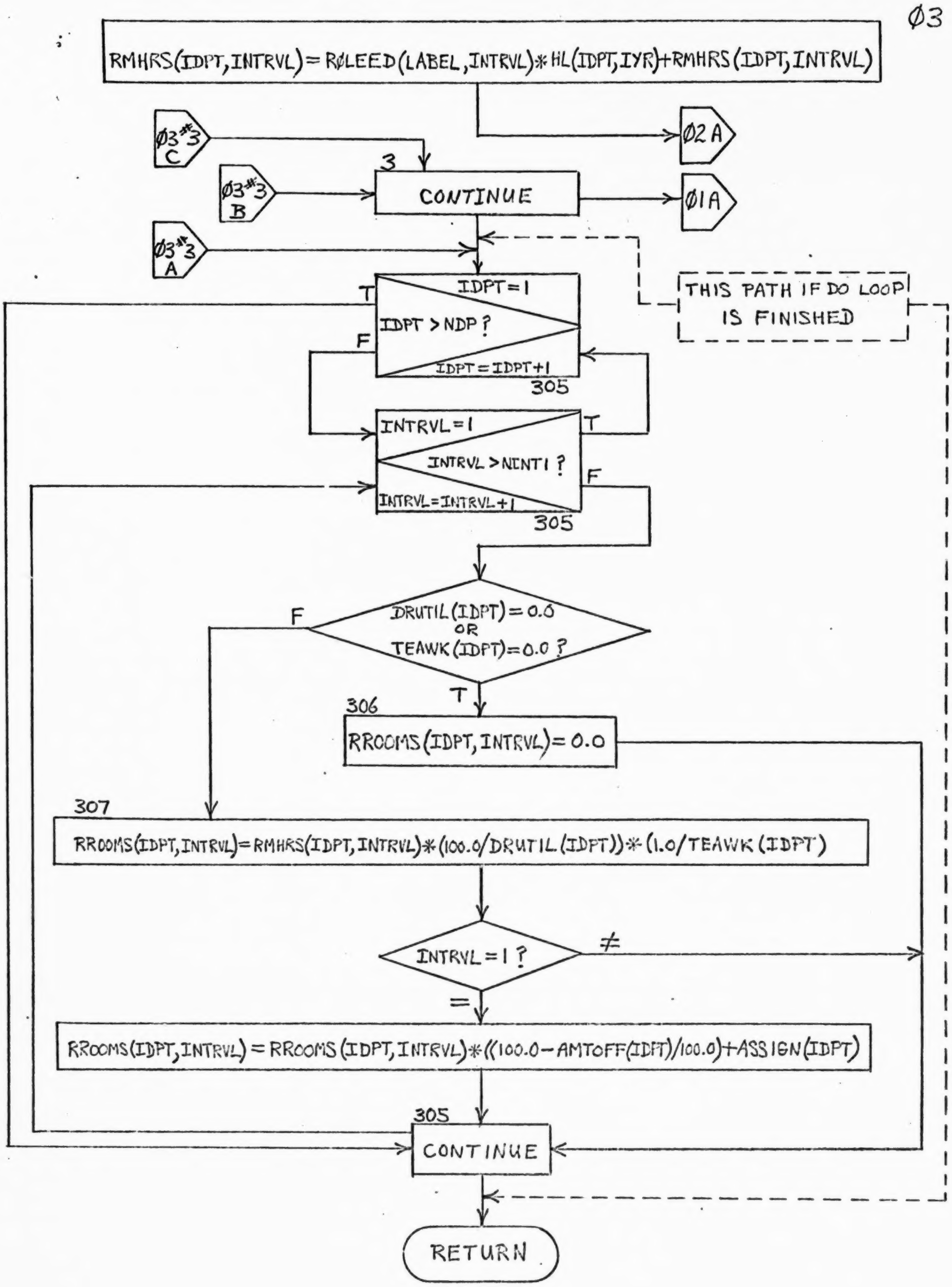

TOTALC = TOTALC + RMHRTO(INTRVL)
T
RMTOT(INTRVL) ≠ 0.0 ?
F
ROMEAN(INTRVL) = 0.0
37
ROMEAN(INTRVL) = SEATOT(INTRVL)/RMTOT(INTRVL)
36
CONTINUE
F5A
F6A
WRITE
80
COLUMN HEADINGS
T
INTRVL = 1
INTRVL > NINTI ?
F
INTRVL = INTRVL + 1
32
IJ = INTRVL + 1
AVGINT(INTRVL) = SQFTOT(INTRVL) / SEATOT(INTRVL)
WRITE
BINT(INTRVL), BINT(IJ), RMTOT(INTRVL)
SEATOT(INTRVL), RMHRTO (INTRVL),
SQFTOT (INTRVL), AVGINT(INTRVL),
ROMEAN(INTRVL)
81
WRITE
NTAG, TOTALA,
TOTALC, TOTALB,
AVGSQF
82
RETURN

```
C***********************************************************************
C      SUBROUTINE FACIL.  A ROUTINE TO UPDATE THE LECTURE ROOM FACILITIES
C      INVENTORY, CALCULATE VARIOUS STATISTICS, AND GENERATE YEARLY A LECTURE
C      ROOM FACILITIES REPORT.
C***********************************************************************
       SUBROUTINE FACIL
       COMMON BLDG(250,3),NBLDG(250),NROOM(250),CCOST(7),   SEATS(250),
      *NODEPT(250),NRES(250),NUPDTE(250),SQFT(250),SQPERS(250),
      *DEVIAT(250),BBLDG(250,3),LBLDG(250),LROOM(250),ROMEAN(7),
      *SSEATS(250),LODEPT(250),LRES(250),LUPDTE(250),SSQFT(250),
      *NCHECK(250),LCHECK(250),RMTOT(7),SEATOT(7),RMHRTO(7),RMHRS(100,7),
      *ITEST(100,9),ROLEFS(100,9),STR(100,9),HL(100,9),ROMHRS(100,9),
      *FACHRS(20,7),AMTOFF(100),ROLEED(250,7),DIST(250,7),BINT(8),
      *FACRMS(20,7),AMIDPT(7),URMS(7),DPNAME(100,4),TRMHRS(7),NDIST,NDP,
      *IACA,NINT1,UTEAWK,SUTIL,RUTIL,NTOTAL,NTAG,INIT1,STOREU(250),
      *DRUTIL(100),TEAWK(100),ASSIGN(100)   ,BLDPRI(100,5),AVGISS(100,7),
      *REMRMS(100,7),RROOMS(100,7),SUTILZ(250),              NPRIOR,
      *RMSASN(7),DIFFHR(7),DIFFRM(7),HRUTIL(7),HRDEV(7),HRLACK(7)
      *,CINT(8),SQFTOT(7),RMTOTC(7),AVGINT(7), SIMYR,CPRMS(7),CPSEAT(7),
      *CPRMHR(7),UNSATI(7),CPDEV(7),SUSIZE(7),NDPFAC(20),NFAC(250),
      *LFAC(250),FACNAM(20,4),MATCHE(7),NOTMAT(7),PERMAT(7),NFACUL,
      *EFFMAT,EFFSAT,SUMMAX(20),PERSAT(7),RMDIFF(10,7),SKIP,SSTOP,IEND,
      *IBEGIN,COSTIN,COSTOT,ISIMYR,ROUND,MROUND,SULOW,BLDPER,CSQFT(7),
      *NINT2,OVERSU,DINT(8),RMTOTD(7),SULOWD,THIS
       REAL NRES,LRES,NBLDG,LBLDG,NROOM,LROOM
C***********************************************************************
C      EACH LECTURE ROOM CARRIES A THREE DIGIT CODE FOR UPDATING PURPOSES.
C      THIS CODE REFLECTS PHYSICAL PLANT DEPARTMENT DECISIONS ON THE STATUS OF
C      UNIVERSITY LECTURE, SEMINAR, AND TUTORIAL ROOM FACILITIES. IF THE FIRST
C      DIGIT IS 0 - INDICATES NO CHANGE IN ROOM STATUS
C               1 - INDICATES CONSTRUCTION OF A ROOM
C               2 - INDICATES RAZING OF A ROOM
C               3 - INDICATES ROOM RENOVATION
C      THE SECOND AND THIRD DIGITS INDICATE THE YEAR THE ROOM IS TO BE ADDED,
C      DELETED, OR TEMPORARILY REMOVED FROM THE EXISTING ROOM INVENTORY. THE
C      FOLLOWING STATEMENTS EXAMINE THE ROOM UPDATING CODE, CREATE A YEARLY SUB-
C      INVENTORY OF NTAG ROOMS FROM THE COMPLETE INVENTORY OF NTOTAL ROOMS, AND
C      PRINT A LISTING OF THESE NTAG ROOMS.
C***********************************************************************
       NTAG=0
       DO 40 I=1,NTOTAL
       IF(NUPDTE(I).EQ.0) GO TO 41
       IF(NUPDTE(I).GE.100.AND.NUPDTE(I).LT.200.AND.(NUPDTE(I)-100-
      *INIT1).LE.0) GO TO 41
       IF(NUPDTE(I).GE.200.AND.NUPDTE(I).LT.300.AND.(NUPDTE(I)-200-
      *INIT1).GT.0) GO TO 41
       IF(NUPDTE(I).GE.300.AND.NUPDTE(I).LT.400.AND.(NUPDTE(I)-300-
      *INIT1).NE.0) GO TO 41
       GO TO 40
    41 NTAG=NTAG+1
       DO 35 J=1,3
       BBLDG(NTAG,J)=BLDG(I,J)
    35 CONTINUE
       LBLDG(NTAG)=NBLDG(I)
       LROOM(NTAG)=NROOM(I)
       SSEATS(NTAG)=SEATS(I)
       LODEPT(NTAG)=NODEPT(I)
       LRES(NTAG)=NRES(I)
       LUPDTE(NTAG)=NUPDTE(I)
       SSQFT(NTAG)=SQFT(I)
      LCHECK(NTAG)=NCHECK(I)
      LFAC(NTAG)=NFAC(I)
   40 CONTINUE
C***********************************************************************
C     AVGSQF= THE AVERAGE NUMBER OF SQUARE FEET/SEAT OVER ALL SIZE INTERVALS
C     TOTALA= TOTAL NUMBER OF LECTURE ROOM SEATS IN THE UNIVERSITY
C     TOTALB= TOTAL SQUARE FOOTAGE OF LECTURE ROOM SPACE
C***********************************************************************
      TOTALA=0.0
      TOTALB=0.0
      DO 50 J=1,NTAG
      SQPERS(J)=SSQFT(J)/SSEATS(J)
      TOTALA=TOTALA+SSEATS(J)
   50 TOTALB=TOTALB+SSQFT(J)
      AVGSQF=TOTALB/TOTALA
      INIT2=INIT1+1
      WRITE(6,105)INIT1,INIT2
  105 FORMAT(1H1,47X,23HUNIVERSITY  OF  TORONTO//,
     *37X,44HC.A.M.P.U.S.  SIMULATION  PLANNING  ANALYSIS///,38X,
     *41HUNIVERSITY LECTURE ROOM FACILITIES REPORT/,38X,41H-------------
     *--------------------          /,52X,8HTERM  19I2,1H-I2///)
      WRITE(6,106)
  106 FORMAT(3X,13HBUILDING NAME,4X,9HBLDG. NO.,3X,8HROOM NO.,3X,
     *5HSEATS,3X,17HFAC.,DEPT. AFFIL.,3X,10HRES. HOURS,3X,7HSQ. FT.,3X,
     *12HSQ. FT./SEAT,3X,14HDEV. FROM AVG.)
      DO 51 J=1,NTAG
      DEVIAT(J)=SQPERS(J)-AVGSQF
      WRITE(6,101)(BBLDG(J,K),K=1,3),LBLDG(J),LROOM(J),SSEATS(J),
     *LFAC(J),LODEPT(J),LRES(J),SSQFT(J),SQPERS(J),DEVIAT(J)
  101 FORMAT(1X,3A6,4X,A4,5X,A6,5X,F5.0,4X,I2,4X,I3,13X,F4.0,6X,F7.0,6X,
     *F5.1,11X,F5.1)
   51 CONTINUE
      WRITE(6,102)
  102 FORMAT(1H0,66HABOVE LIST REPRESENTS LECTURE ROOMS AVAILABLE FOR TH
     *E CURRENT TERM//)
      WRITE(6,103)TOTALB,TOTALA,AVGSQF
  103 FORMAT(1X,37HAVERAGE NUMBER OF SQ. FT. PER SEAT ISF10.1,1H/,F7.0,
     *2H =,F5.1,2X,53HDEVIATION FOR EACH ROOM IS MEASURED FROM THIS AVER
     *AGE)
C***********************************************************************
C     THE FOLLOWING STATEMENTS COMPUTE CERTAIN INFORMATION ON THE LECTURE ROOM
C     FACILITIES FOR EACH SIZE INTERVAL.
C     RMTOT = THE TOTAL NUMBER OF ROOMS IN EACH SIZE INTERVAL
C     SEATOT= THE TOTAL NUMBER OF SEATS IN EACH SIZE INTERVAL
C     RMHRTO= THE TOTAL NUMBER OF ROOM-HOURS IN EACH SIZE INTERVAL
C     SQFTOT= THE TOTAL NUMBER OF SQUARE FEET IN EACH SIZE INTERVAL
C     RMTOTC= THE TOTAL NUMBER OF ROOMS IN EACH MODIFIED SIZE INTERVAL
C     TOTALC= TOTAL NUMBER OF ROOM-HOURS AVAILABLE FOR TEACHING
C     AVGINT= THE AVERAGE NUMBER OF SQUARE FEET/SEAT FOR EACH SIZE INTERVAL
C     ROMEAN= THE AVERAGE ROOM SIZE IN EACH SIZE RANGE
C***********************************************************************
      DO 30 INTRVL=1,NINT1
      IJ=INTRVL+1
      RMTOT(INTRVL)=0.0
      SEATOT(INTRVL)=0.0
      RMHRTO(INTRVL)=0.0
      SQFTOT(INTRVL)=0.0
      DO 30 K=1,NTAG
      IF(SSEATS(K).LT.BINT(IJ).AND.SSEATS(K).GE.BINT(INTRVL))GO TO 31
      GO TO 30
   31 RMTOT(INTRVL)=RMTOT(INTRVL)+1.0
      SEATOT(INTRVL)=SEATOT(INTRVL)+SSEATS(K)
      RMHRTO(INTRVL)=RMHRTO(INTRVL)+UTEAWK-LRES(K)
      SQFTOT(INTRVL)=SQFTOT(INTRVL)+SSQFT(K)
   30 CONTINUE
      DO 33 INTRVL=1,NINT1
      IJ=INTRVL+1
      RMTOTC(INTRVL)=0.0
      DO 33 K=1,NTAG
      IF(SSEATS(K).LT.CINT(IJ).AND.SSEATS(K).GE.BINT(INTRVL)) GO TO 34
      GO TO 33
   34 RMTOTC(INTRVL)=RMTOTC(INTRVL)+1.0
   33 CONTINUE
      DO 140 INTRVL=1,NINT1
      IJ=INTRVL+1
      RMTOTD(INTRVL)=0.0
      DO 140 K=1,NTAG
      IF(SSEATS(K).LT.DINT(IJ).AND.SSEATS(K).GE.DINT(INTRVL))GO TO 141
      GO TO 140
  141 RMTOTD(INTRVL)=RMTOTD(INTRVL)+1.0
  140 CONTINUE
      TOTALC=0.0
      DO 36 INTRVL=1,NINT1
      TOTALC=TOTALC+RMHRTO(INTRVL)
      IF(RMTOT(INTRVL).NE.0.0) GO TO 37
      ROMEAN(INTRVL)=0.0
      GO TO 36
   37 ROMEAN(INTRVL)=SEATOT(INTRVL)/RMTOT(INTRVL)
   36 CONTINUE
C*************************************************************************
C     PRINT A REPORT OF THE INFORMATION CALCULATED FOR EACH SIZE INTERVAL.
C*************************************************************************
      WRITE(6,80)
   80 FORMAT(///47X, 23HBREAKDOWN BY SIZE RANGE/,47X,23H----------------
     *-------//,1X,14HSIZE(STUDENTS),4X,12HNO. OF ROOMS,4X,12HNO. OF SEA
     *TS,4X,23HTOTAL ROOM-HOURS AVAIL.,4X,14HNO. OF SQ. FT.,3X,
     *20HAVERAGE SQ. FT./SEAT,3X,14HMEAN ROOM SIZE//)
      DO 32 INTRVL=1,NINT1
      IJ=INTRVL+1
      AVGINT(INTRVL)=SQFTOT(INTRVL)/SEATOT(INTRVL)
      WRITE(6,81)BINT(INTRVL),BINT(IJ),RMTOT(INTRVL),SEATOT(INTRVL),
     *RMHRTO(INTRVL),SQFTOT(INTRVL),AVGINT(INTRVL),ROMEAN(INTRVL)
   81 FORMAT(1X,F5.0,4H TO ,F5.0,7X,F5.0,11X,F6.0,14X,F7.1,16X,F8.1,
     *14X,F5.1,15X,F6.1)
   32 CONTINUE
      WRITE(6,82)NTAG,TOTALA,TOTALC,TOTALB,AVGSQF
   82 FORMAT(21X,7H-------,9X,8H--------,12X,9H---------,14X,10H--------
     *--,12X,7H-------/,16X,6HTOTAL ,I4,11H      TOTAL ,F7.0,13H        TO
     *TAL ,F8.1,14H        TOTAL ,F10.1,14H OVERALL AVG.,F5.1)
      RETURN
      END

  171*CARDS
```


SUBROUTINE
ENTER
ORCAST
ENROLLMENT INPUT DISTRIBUTION PRESENT ?
NO
YES
NUMBER OF SECTIONS =ENROLLEES/CLASS SIZE
APPLY INPUT DISTRIBUTION =ENROLLEES BY SIZE INTERVAL
ROOM-HOURS=NUMBER OF SECTIONS * HOURS/WEEK/SECTION
DIVIDE BY INTERVAL MIDPOINTS =NUMBER OF SECTIONS
INSERT ROOM-HOURS INTO A SIZE INTERVAL DETERMINED BY CLASS SIZE
ROOM-HOURS=NUMBER OF SECTIONS IN INTERVAL * HOURS/WEEK/SECTION
SUM ROOM-HOURS
ROOMS OF EACH SIZE RANGE =ROOM-HOURS/TEACHING WEEK * 100.0/DEPARTMENTAL ROOM UTILIZATION
SIZE INTERVAL I. ?
NO
YES
ADJUST ROOM REQUIREMENTS BY AMTOFF AND ASSIGN
RETURN

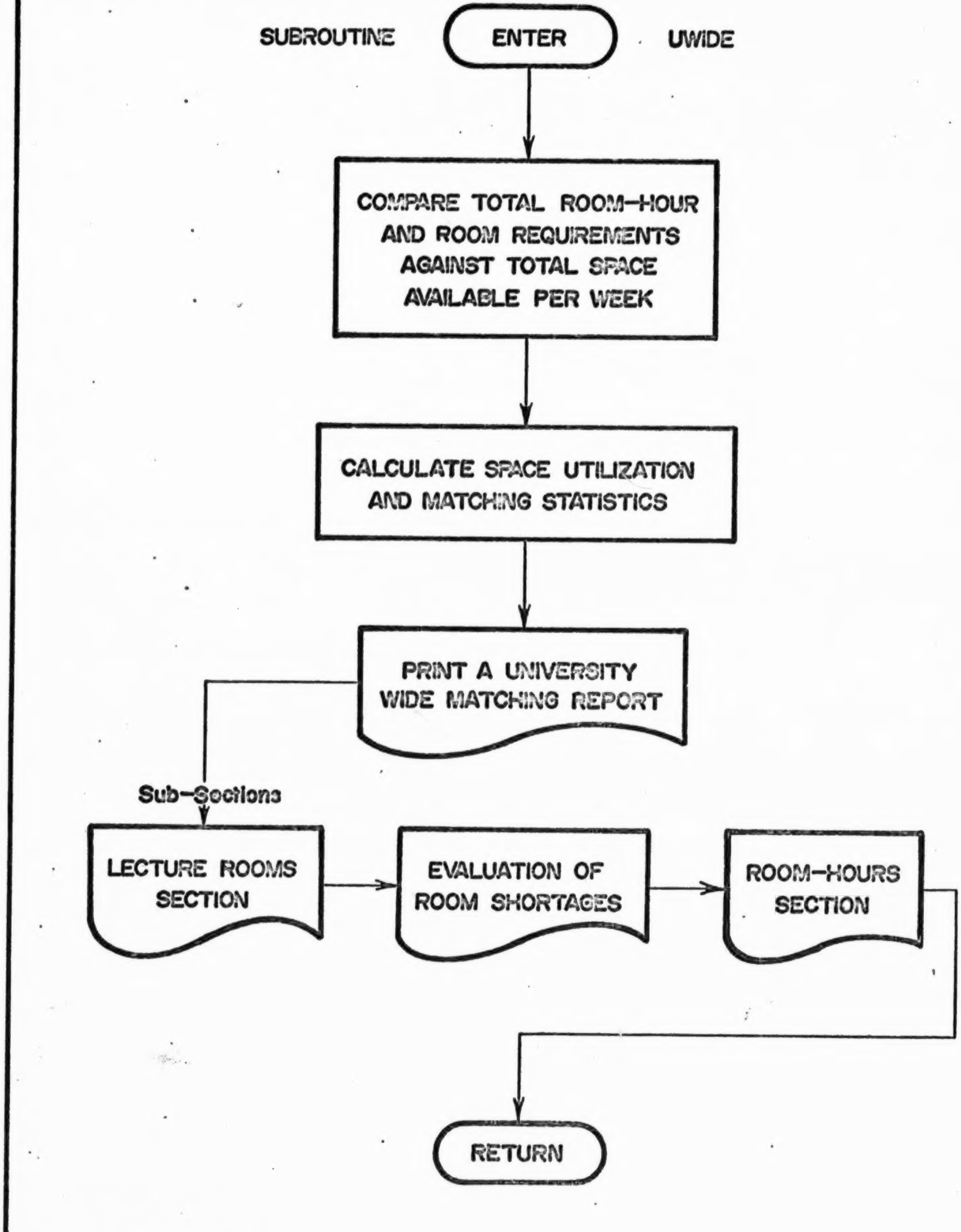

ENTER
T
IDPT = 1
IDPT > NDP?
F
IDPT = IDPT+1
1
INTRVL=1
T
INTRVL>NINT1?
INTRVL
=INTRVL+1
F
1
RMHRS(IDPT,INTRVL) = 0.0
LABEL = 0
03 #3 A
T
IDPT=1
IDPT > NDP?
F
IDPT=IDPT+1
3
IYR=1
T
01A
IYR>IACA?
F
IYR=IYR+1
3
ITEST(IDPT,IYR)=0?
=
02 #6
≠
LABEL = LABEL + 1
02 #5
02

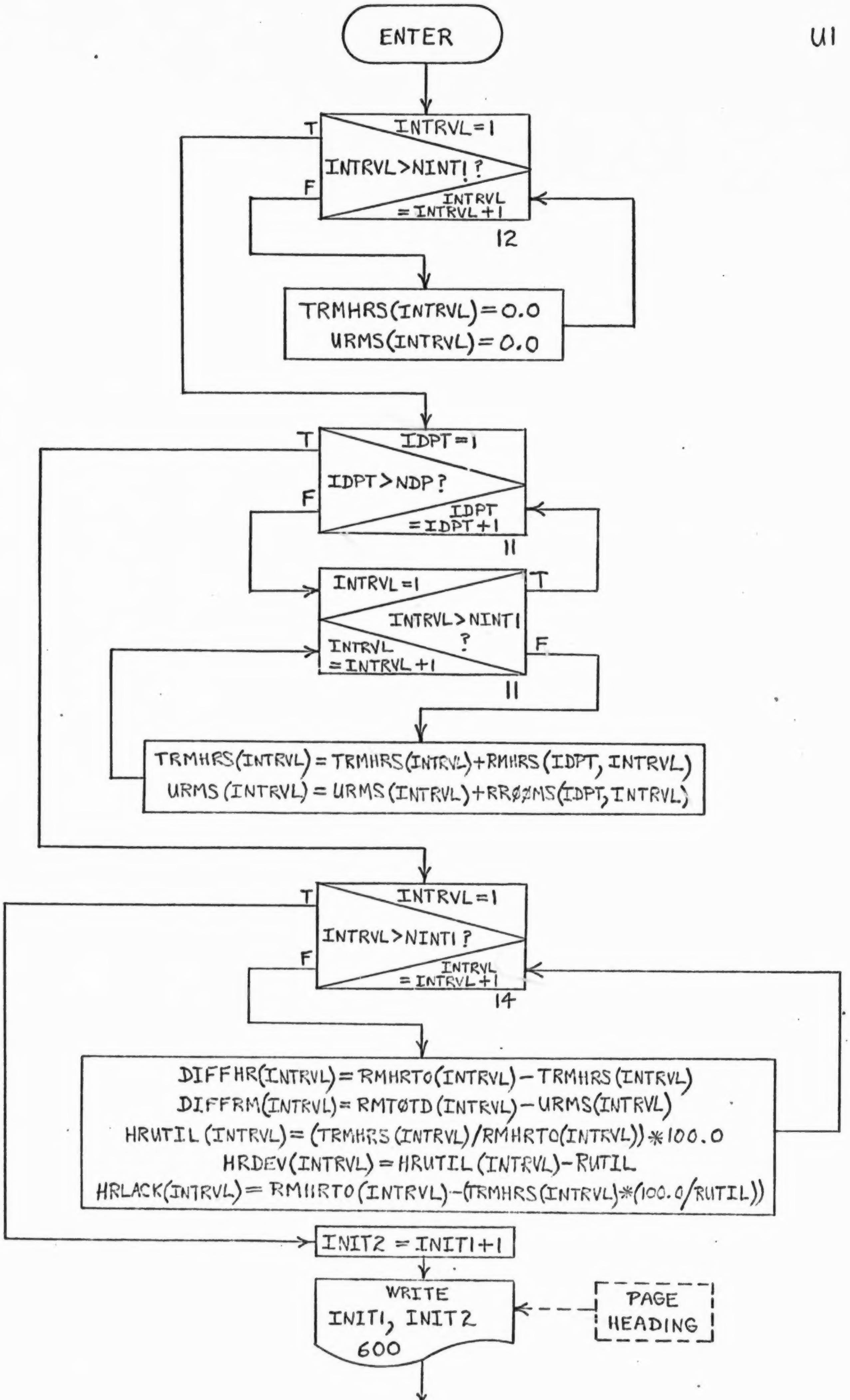

Ø2 #6
6
≠
STR(IDPT,IYR)≠0 ?
=
RØMHRS(IDPT,IYR)= 0.0
66
RØMHRS(IDPT,IYR)=HL(IDPT,IYR)*ROLEES(IDPT,IYR)/STR(IDPT, IYR)
65
T
INTRVL=1
INTRVL>NINT1 ?
F
INTRVL =INTRVL+1
4
II= INTRVL+1
STR(IDPT,IYR)<BINT(II) AND STR(IDPT,IYR)>BINT(INTRVL) ?
F
T
7
RMHRS(IDPT,INTRVL) = RMHRS(IDPT,INTRVL)+RØMHRS(IDPT,IYR)
Ø3 #3 C
Ø2 #5
5
T
INTRVL=1
Ø3 #3 B
INTRVL>NINT1 ?
F
INTRVL =INTRVL+1
Ø2A
8
RØLEED(LABEL,INTRVL)=RØLEES(IDPT,IYR)*(DIST(LABEL,INTRVL)/100.0)/AMIDPT(INTRVL)
Ø3

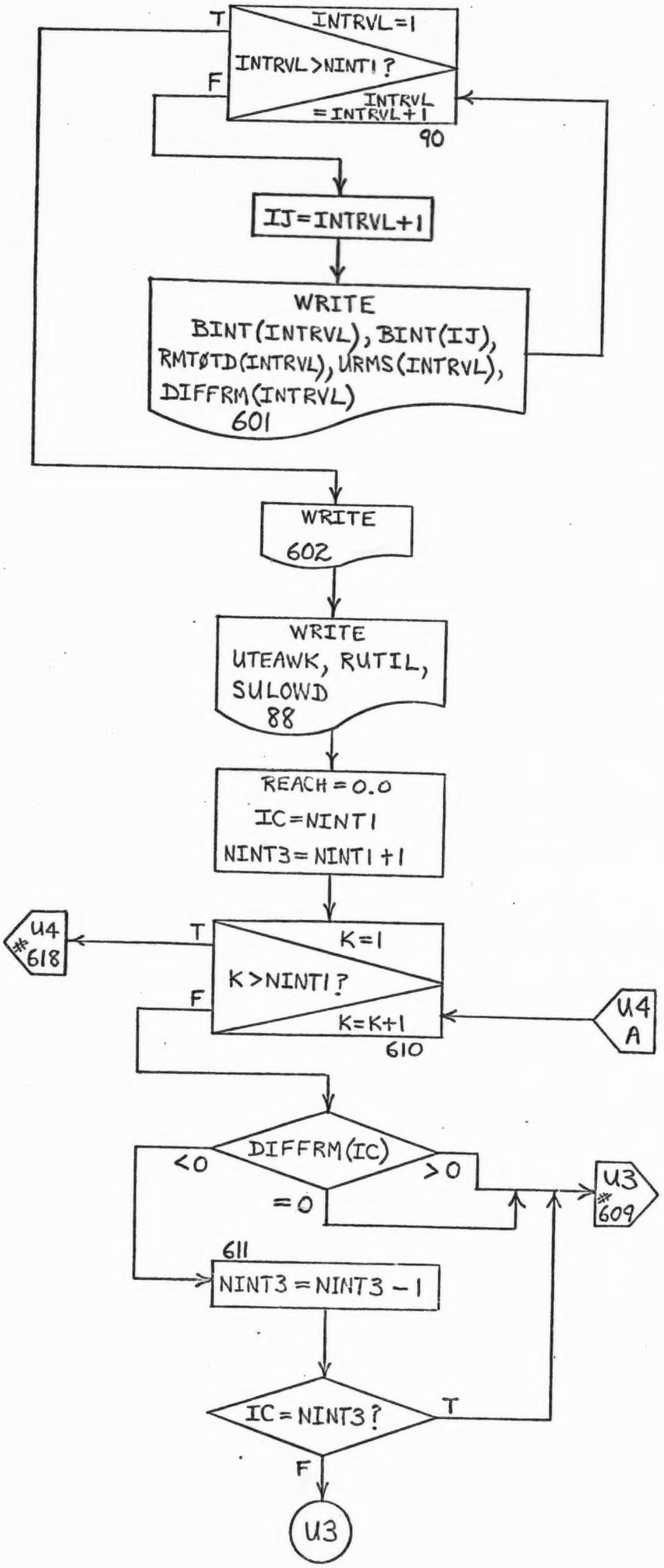

RMHRS(IDPT,INTRVL) = RØLEED(LABEL,INTRVL)*HL(IDPT,IYR)+RMHRS(IDPT,INTRVL)
Ø2 A
Ø3 #3 C
3
Ø3 #3 B
CONTINUE
Ø1 A
Ø3 #3 A
T
IDPT=1
IDPT > NDP ?
F
IDPT = IDPT+1
305
THIS PATH IF DO LOOP IS FINISHED
INTRVL=1
T
INTRVL > NINT1 ?
F
INTRVL=INTRVL+1
305
F
DRUTIL(IDPT) = 0.0 OR TEAWK(IDPT)=0.0 ?
T
306
RROOMS(IDPT,INTRVL) = 0.0
307
RROOMS(IDPT,INTRVL)=RMHRS(IDPT,INTRVL)*(100.0/DRUTIL(IDPT))*(1.0/TEAWK(IDPT)
INTRVL = 1 ?
≠
=
RROOMS(IDPT,INTRVL) = RROOMS(IDPT,INTRVL)*((100.0−AMTOFF(IDPT)/100.0)+ASSIGN(IDPT)
305
CONTINUE
RETURN
)

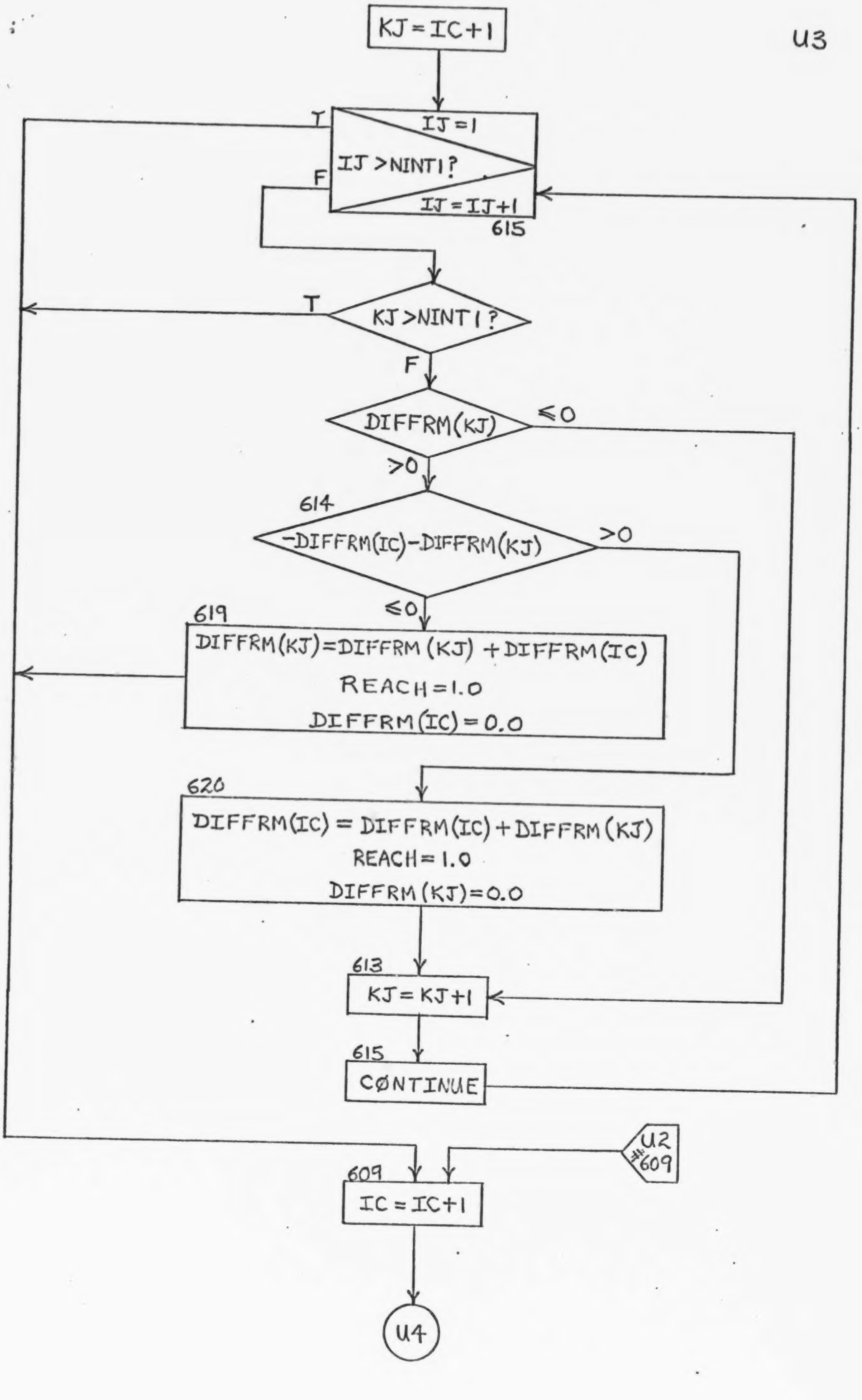
```
C*****************************************************************************
C.    SUBROUTINE ORCAST.  A ROUTINE TO FORECAST THE NUMBER OF ROOM-HOURS AND THE
C     NUMBER OF ROOMS REQUIRED BY A DEPARTMENT IN EACH SIZE INTERVAL.
C*****************************************************************************
      SUBROUTINE ORCAST
      COMMON BLDG(250,3),NBLDG(250),NROOM(250),CCOST(7),   SEATS(250),
     *NODEPT(250),NRES(250),NUPDTE(250),SQFT(250),SQPERS(250),
     *DEVIAT(250),BBLDG(250,3),LBLDG(250),LROOM(250),ROMEAN(7),
     *SSEATS(250),LODEPT(250),LRES(250),LUPDTE(250),SSQFT(250),
     *NCHECK(250),LCHECK(250),RMTOT(7),SEATOT(7),RMHRTO(7),RMHRS(100,7),
     *ITEST(100,9),ROLEES(100,9),STR(100,9),HL(100,9),ROMHRS(100,9),
     *FACHRS(20,7),AMTOFF(100),ROLEED(250,7),DIST(250,7),BINT(8),
     *FACRMS(20,7),AMIDPT(7),URMS(7),DPNAME(100,4),TRMHRS(7),NDIST,NDP,
     *IACA,NINT1,UTEAWK,SUTIL,RUTIL,NTOTAL,NTAG,INIT1,STOREU(250),
     *DRUTIL(100),TEAWK(100),ASSIGN(100)   ,BLDPRI(100,5),AVGISS(100,7),
     *REMRMS(100,7),RROOMS(100,7),SUTILZ(250),             NPRIOR,
     *RMSASN(7),DIFFHR(7),DIFFRM(7),HRUTIL(7),HRDEV(7),HRLACK(7)
     *,CINT(8),SQFTOT(7),RMTOTC(7),AVGINT(7), SIMYR,CPRMS(7),CPSEAT(7),
     *CPRMHR(7),UNSATI(7),CPDEV(7),SUSIZE(7),NDPFAC(20),NFAC(250),
     *LFAC(250),FACNAM(20,4),MATCHE(7),NOTMAT(7),PERMAT(7),NFACUL,
     *EFFMAT,EFFSAT,SUMMAX(20),PERSAT(7),RMDIFF(10,7),SKIP,SSTOP,IEND,
     *IBEGIN,COSTIN,COSTOT,ISIMYR,ROUND,MROUND,SULOW,BLDPER,CSQFT(7),
     *NINT2,OVERSU,DINT(8),RMTOTD(7),SULOWD,THIS
      REAL NRES,LRES,NBLDG,LBLDG,NROOM,LROOM
C*****************************************************************************
C     INITIALIZE ROOM HOURS MATRIX
C     CHECK TO SEE IF AN INPUT DISTRIBUTION IS PROVIDED FOR EACH DEPARTMENT AND
C     ACADEMIC YEAR . IF ITEST= 1, AN INPUT DISTRIBUTION IS USED TO DIVIDE THE
C     FORECASTED ENROLLMENT INTO THE VARIOUS ROOM SIZE INTERVALS. IF ITEST=0,
C     THE FORECASTED ENROLLMENT IS INSERTED INTO A SIZE INTERVAL SPECIFIED BY
C     THE AVERAGE CLASS SIZE.
C*****************************************************************************
      DO 1 IDPT=1,NDP
      DO 1 INTRVL=1,NINT1
      RMHRS(IDPT,INTRVL)=0.0
    1 CONTINUE
      LABEL=0
      DO 3 IDPT=1,NDP
      DO 3 IYR=1,IACA
      IF(ITEST(IDPT,IYR).EQ.0) GO TO 6
      LABEL=LABEL+1
      GO TO 5
C*****************************************************************************
C      ITEST=0  CALCULATE THE NUMBER OF SECTIONS IN AN ACADEMIC YEAR BY DIVIDING
C               FORECASTED ENROLEES(ROLEES) BY FORECASTED CLASS SIZE(STR).
C               OBTAIN ROOM-HOURS REQUIRED BY MULTIPLYING BY FORECASTED
C               HOURS/WEEK/SECTION(HL), THEN INSERT THIS REQUIREMENT INTO A ROOM
C               SIZE INTERVAL DETERMINED BY CLASS SIZE.
C*****************************************************************************
    6 IF(STR(IDPT,IYR).NE.0.0) GO TO 66
      ROMHRS(IDPT,IYR)=0.0
      GO TO 65
   66 ROMHRS(IDPT,IYR)=HL(IDPT,IYR)*ROLEES(IDPT,IYR)/STR(IDPT,IYR)
   65 DO 4 INTRVL=1,NINT1
      II=INTRVL+1
      IF(STR(IDPT,IYR).LT.BINT(II).AND.STR(IDPT,IYR).GE.
     *BINT(INTRVL)) GO TO 7
    4 CONTINUE
    7 RMHRS(IDPT,INTRVL)=RMHRS(IDPT,INTRVL)+ROMHRS(IDPT,IYR)
      GO TO 3
```

```
C*******************************************************************************
C     ITEST=1  BREAK THE FORECASTED ENROLEES INTO THE VARIOUS SIZE INTERVALS BY
C              APPLYING THE GIVEN INPUT DISTRIBUTION. CALCULATE THE NUMBER OF
C              SECTIONS REQUIRED BY DIVIDING BY THE MIDPOINT OF THE INTERVAL.
C              FINALLY COMPUTE THE ROOM-HOURS REQUIRED BY MULTIPLYING THE
C              NUMBER OF SECTIONS PER INTERVAL BY HOURS/SECTION/WEEK.
C*******************************************************************************
    5 DO 8 INTRVL=1,NINT1
      ROLEED(LABEL,INTRVL)=ROLEES(IDPT,IYR)*(DIST(LABEL,INTRVL)/100.0)
     */AMIDPT(INTRVL)
      RMHRS(IDPT,INTRVL)=ROLEED(LABEL,INTRVL)*HL(IDPT,IYR)+
     *RMHRS(IDPT,INTRVL)
    8 CONTINUE
    3 CONTINUE
C*******************************************************************************
C     DETERMINE THE NUMBER OF DEPARTMENTAL ROOMS OF EACH SIZE RANGE REQUIRED BY
C     DIVIDING BY THE DEPARTMENTAL TEACHING WEEK LENGIH AND APPLYING A DEPARI-
C     MENTAL ROOM UTILIZATION FACTOR. ADD ANY ADDITIONAL ROOMS REQUIRED BY A
C     DEPARTMENT (SPECIFIED BY THE ARRAY ASSIGN), AND DEDUCT A PROPORTION OF
C     SEMINAR AND TUTORIAL ROOM REQUIREMENTS TAKING COGNIZANCE OF THE FACT THAT
C     VERY SMALL CLASSES ARE OFTEN HELD IN PROFESSORS- OFFICES.
C*******************************************************************************
      DO 305 IDPT=1,NDP
      DO 305 INTRVL=1,NINT1
      IF(DRUTIL(IDPT).EQ.0.0.OR.TEAWK(IDPT).EQ.0.0) GO TO 306
      GO TO 307
  306 RROOMS(IDPT,INTRVL)=0.0
      GO TO 305
  307 RROOMS(IDPT,INTRVL)=RMHRS(IDPT,INTRVL)*(100.0/DRUTIL(IDPT))*(1.0/
     *TEAWK(IDPT))
      IF(INTRVL.EQ.1)RROOMS(IDPT,INTRVL)=RROOMS(IDPT,INTRVL)*((100.0-
     *AMTOFF(IDPT))/100.0)+ASSIGN(IDPT)
  305 CONTINUE
      RETURN
      END

    95*CARDS
```

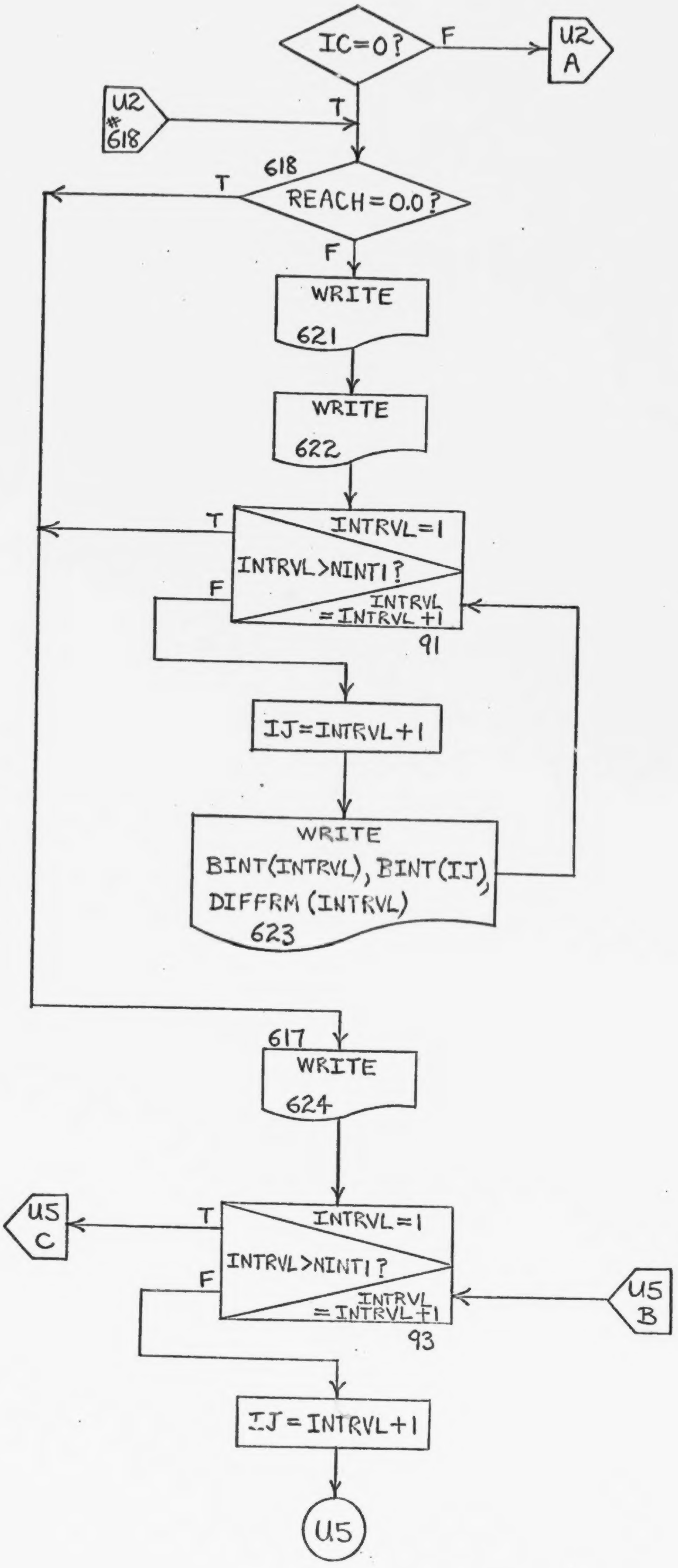

SUBROUTINE
ENTER
UWIDE
COMPARE TOTAL ROOM-HOUR AND ROOM REQUIREMENTS AGAINST TOTAL SPACE AVAILABLE PER WEEK
CALCULATE SPACE UTILIZATION AND MATCHING STATISTICS
PRINT A UNIVERSITY WIDE MATCHING REPORT
Sub-Sections
LECTURE ROOMS SECTION
EVALUATION OF ROOM SHORTAGES
ROOM-HOURS SECTION
RETURN

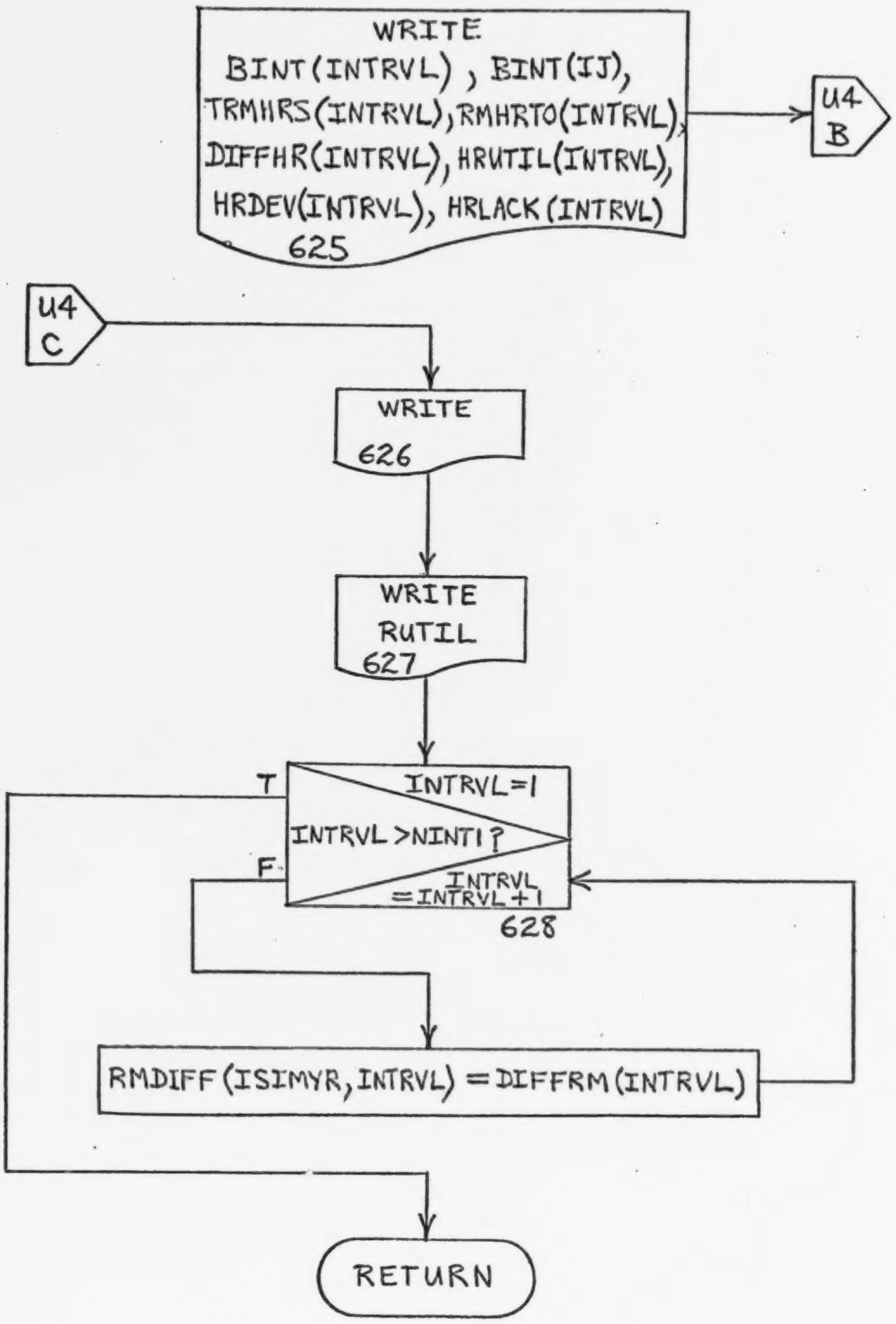

ENTER
T
INTRVL=1
INTRVL>NINT1 ?
F
INTRVL = INTRVL+1
12
TRMHRS(INTRVL)=0.0
URMS(INTRVL)=0.0
T
IDPT=1
IDPT>NDP ?
F
IDPT =IDPT+1
11
INTRVL=1
T
INTRVL>NINT1 ?
F
INTRVL =INTRVL+1
11
TRMHRS(INTRVL) = TRMHRS(INTRVL)+RMHRS(IDPT, INTRVL)
URMS(INTRVL) = URMS(INTRVL)+RRØ0MS(IDPT, INTRVL)
T
INTRVL=1
INTRVL>NINT1 ?
F
INTRVL =INTRVL+1
14
DIFFHR(INTRVL)=RMHRTO(INTRVL)-TRMHRS(INTRVL)
DIFFRM(INTRVL)=RMTØTD(INTRVL)-URMS(INTRVL)
HRUTIL(INTRVL)=(TRMHRS(INTRVL)/RMHRTO(INTRVL))*100.0
HRDEV(INTRVL)=HRUTIL(INTRVL)-RUTIL
HRLACK(INTRVL)=RMHRTO(INTRVL)-(TRMHRS(INTRVL)*(100.0/RUTIL))
INIT2 = INIT1+1
WRITE
INIT1, INIT2
600
PAGE HEADING
U2


T
INTRVL=1
INTRVL>NINT1?
F
INTRVL
=INTRVL+1
90
IJ=INTRVL+1
WRITE
BINT(INTRVL), BINT(IJ),
RMTØTD(INTRVL), URMS(INTRVL),
DIFFRM(INTRVL)
601
WRITE
602
WRITE
UTEAWK, RUTIL,
SULOWD
88
REACH=0.0
IC=NINT1
NINT3=NINT1+1
U4
#
618
T
K=1
K>NINT1?
F
K=K+1
610
U4
A
DIFFRM(IC)
<0
>0
=0
U3
#
609
611
NINT3=NINT3-1
IC=NINT3?
T
F
U3


KJ = IC+1
T
IJ = 1
IJ > NINT1?
F
IJ = IJ+1
615
T
KJ > NINT1?
F
DIFFRM(KJ)
≤0
>0
614
-DIFFRM(IC)-DIFFRM(KJ)
>0
≤0
619
DIFFRM(KJ)=DIFFRM (KJ) + DIFFRM(IC)
REACH=1.0
DIFFRM(IC)=0.0
620
DIFFRM(IC) = DIFFRM(IC)+DIFFRM (KJ)
REACH=1.0
DIFFRM (KJ)=0.0
613
KJ = KJ+1
615
CØNTINUE
U2
#609
609
IC = IC+1
U4

U4


IC=0?
F
U2
A
U2
#
618
T
618
REACH=0.0?
T
F
WRITE
621
WRITE
622
T
INTRVL=1
INTRVL>NINT1?
F
INTRVL
=INTRVL+1
91
IJ=INTRVL+1
WRITE
BINT(INTRVL), BINT(IJ),
DIFFRM (INTRVL)
623
617
WRITE
624
U5
C
T
INTRVL=1
INTRVL>NINT1?
F
INTRVL
=INTRVL+1
93
U5
B
IJ=INTRVL+1
U5


WRITE
BINT(INTRVL), BINT(IJ),
TRMHRS(INTRVL), RMHRTO(INTRVL),
DIFFHR(INTRVL), HRUTIL(INTRVL),
HRDEV(INTRVL), HRLACK(INTRVL)
625
U4 B
U4 C
WRITE
626
WRITE
RUTIL
627
T
F
INTRVL=1
INTRVL >NINT1 ?
INTRVL =INTRVL+1
628
RMDIFF(ISIMYR, INTRVL) = DIFFRM(INTRVL)
RETURN

```
C***********************************************************************
C     SUBROUTINE UWIDE.  A UNIVERSITY WIDE SUMMARY AND REPORTING ROUTINE.  IT
C     COMPARES FORECASTED ROOM-HOURS AND ROOMS REQUIREMENTS AGAINST THOSE
C     AVAILABLE, CALCULATES MEASURES OF SPACE UTILIZATION, AND GENERATES A
C     UNIVERSITY MATCHING REPORT.
C***********************************************************************
      SUBROUTINE UWIDE
      COMMON BLDG(250,3),NBLDG(250),NROOM(250),CCOST(7),   SEATS(250),
     *NODEPT(250),NRES(250),NUPDTE(250),SQFT(250),SQPERS(250),
     *DEVIAT(250),BBLDG(250,3),LBLDG(250),LROOM(250),ROMEAN(7),
     *SSEATS(250),LODEPT(250),LRES(250),LUPDTE(250),SSQFT(250),
     *NCHECK(250),LCHECK(250),RMTOT(7),SEATOT(7),RMHRTO(7),RMHRS(100,7),
     *ITEST(100,9),ROLEES(100,9),STR(100,9),HL(100,9),ROMHRS(100,9),
     *FACHRS(20,7),AMTOFF(100),ROLEED(250,7),DIST(250,7),BINT(8),
     *FACRMS(20,7),AMIDPT(7),URMS(7),DPNAME(100,4),TRMHRS(7),NDIST,NDP,
     *IACA,NINT1,UTEAWK,SUTIL,RUTIL,NTOTAL,NTAG,INIT1,STOREU(250),
     *DRUTIL(100),TEAWK(100),ASSIGN(100)   ,BLDPRI(100,5),AVGISS(100,7),
     *REMRMS(100,7),RROOMS(100,7),SUTILZ(250),            NPRIOR,
     *RMSASN(7),DIFFHR(7),DIFFRM(7),HRUTIL(7),HRDFV(7),HRLACK(7)
     *,CINT(8),SQFTOT(7),RMTOTC(7),AVGINT(7), SIMYR,CPRMS(7),CPSEAT(7),
     *CPRMHR(7),UNSATI(7),CPDEV(7),SUSIZE(7),NDPFAC(20),NFAC(250),
     *LFAC(250),FACNAM(20,4),MATCHE(7),NOTMAT(7),PERMAT(7),NFACUL,
     *EFFMAT,EFFSAT,SUMMAX(20),PERSAT(7),RMDIFF(10,7),SKIP,SSTOP,IEND,
     *IBEGIN,COSTIN,COSTOT,ISIMYR,ROUND,MROUND,SULOW,BLDPER,CSQFT(7),
     *NINT2,OVERSU,DINT(8),RMTOTD(7),SULOWD,THIS
      REAL NRES,LRES,NBLDG,LBLDG,NROOM,LROOM
C***********************************************************************
C     THE FOLLOWING INFORMATION IS CALCULATED AND REPORTED ON A UNIVERSITY WIDE
C     BASIS.
C     TRMHRS= TOTAL ROOM-HOURS REQUIRED IN EACH ROOM SIZE INTERVAL
C     URMS  = TOTAL NUMBER OF ROOMS OF EACH SIZE REQUIRED
C     DIFFHR= TOTAL ROOM-HOURS AVAILABLE MINUS TOTAL ROOM HOURS REQUIRED
C     DIFFRM= TOTAL ROOMS AVAILABLE MINUS TOTAL ROOMS REQUIRED
C     HRUTIL= UNIVERSITY ROOM-HOUR UTILIZATION
C     HRDEV = DEVIATION OF HRUTIL FROM THE EXPECTED UNIVERSITY ROOM UTILIZATION
C     HRLACK= THE ACTUAL SHORTAGE OR EXCESS OF ROOM-HOURS BY SIZE INTERVAL
C***********************************************************************
      DO 12 INTRVL=1,NINT1
      TRMHRS(INTRVL)=0.0
      URMS(INTRVL)=0.0
   12 CONTINUE
      DO 11 IDPT=1,NDP
      DO 11 INTRVL=1,NINT1
      TRMHRS(INTRVL)=TRMHRS(INTRVL)+RMHRS(IDPT,INTRVL)
      URMS(INTRVL)=URMS(INTRVL)+RROOMS(IDPT,INTRVL)
   11 CONTINUE
      DO 14 INTRVL=1,NINT1
      DIFFHR(INTRVL)=RMHRTO(INTRVL)-TRMHRS(INTRVL)
      DIFFRM(INTRVL)=RMTOTD(INTRVL)-URMS(INTRVL)
      HRUTIL(INTRVL)=(TRMHRS(INTRVL)/RMHRTO(INTRVL))*100.0
      HRDEV(INTRVL)=HRUTIL(INTRVL)-RUTIL
      HRLACK(INTRVL)=RMHRTO(INTRVL)-(TRMHRS(INTRVL)*(100.0/RUTIL))
   14 CONTINUE
C***********************************************************************
C     PRINT A UNIVERSITY WIDE MATCHING REPORT FOR ROOMS.
C***********************************************************************
      INIT2=INIT1+1
      WRITE(6,600)INIT1,INIT2
  600 FORMAT(1H1/47X,23HUNIVERSITY  OF  TORONTO//37X,44HC.A.M.P.U.S.  SI
     *MULATION  PLANNING  ANALYSIS///,30X,59HUNIVERSITY WIDE MATCHING RE
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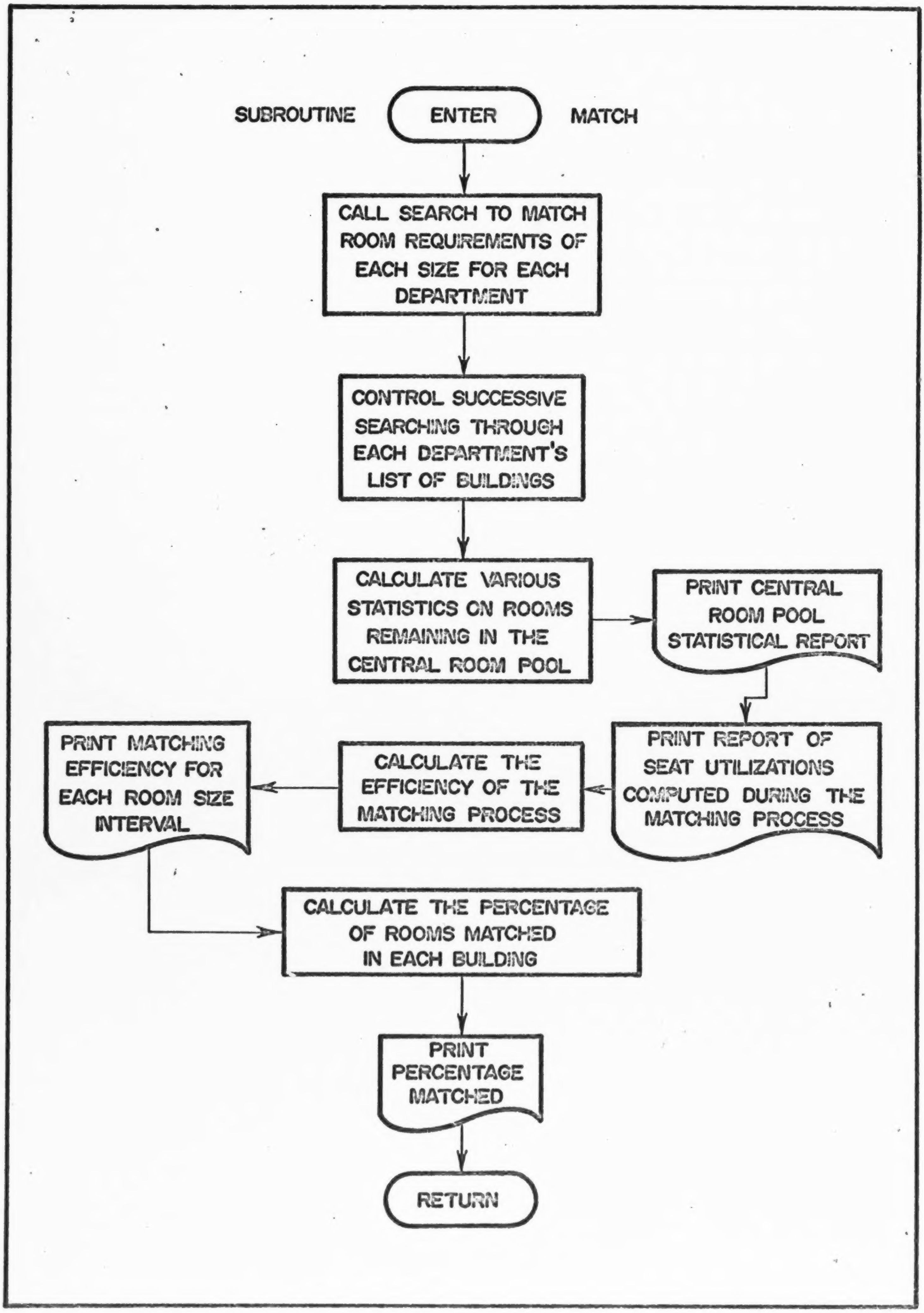
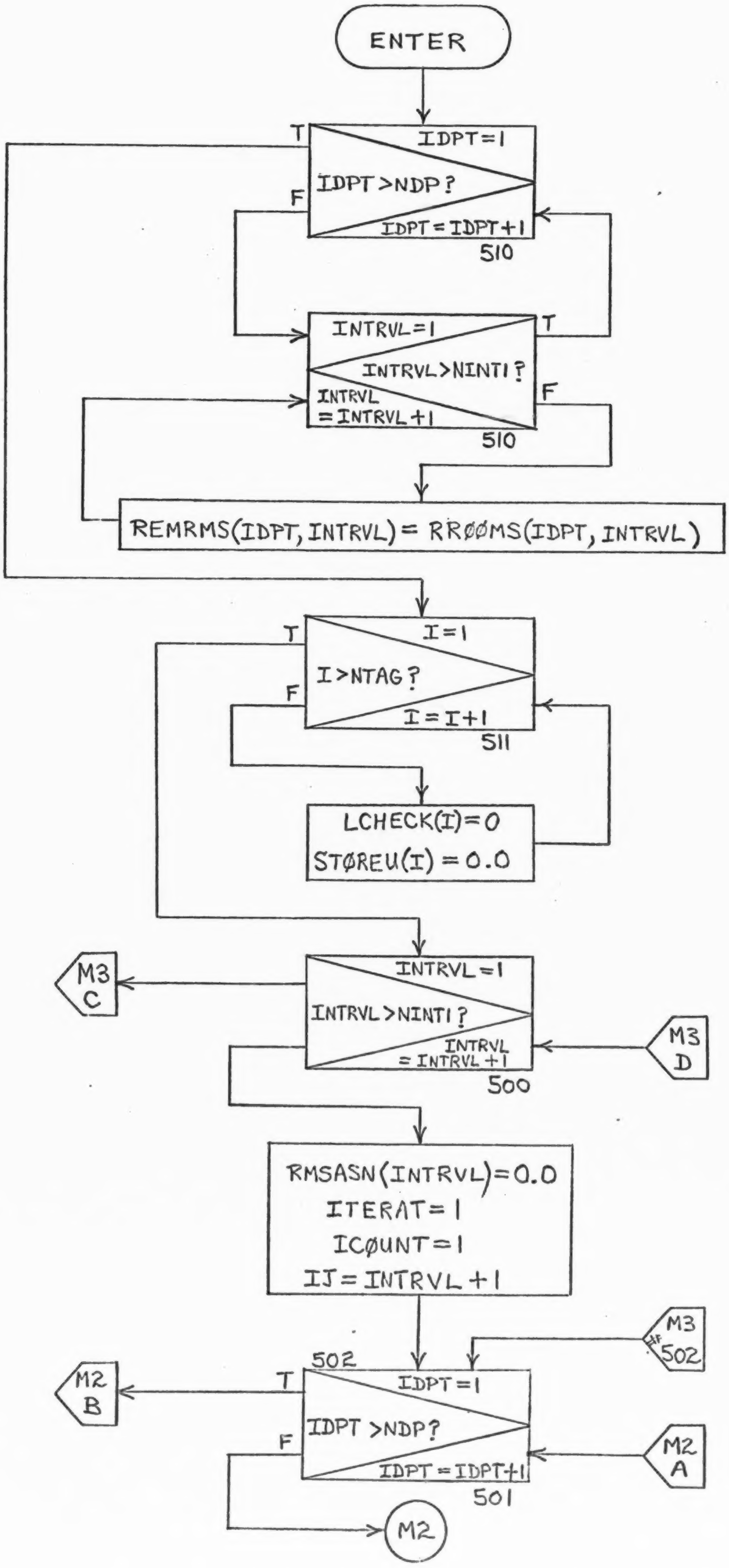
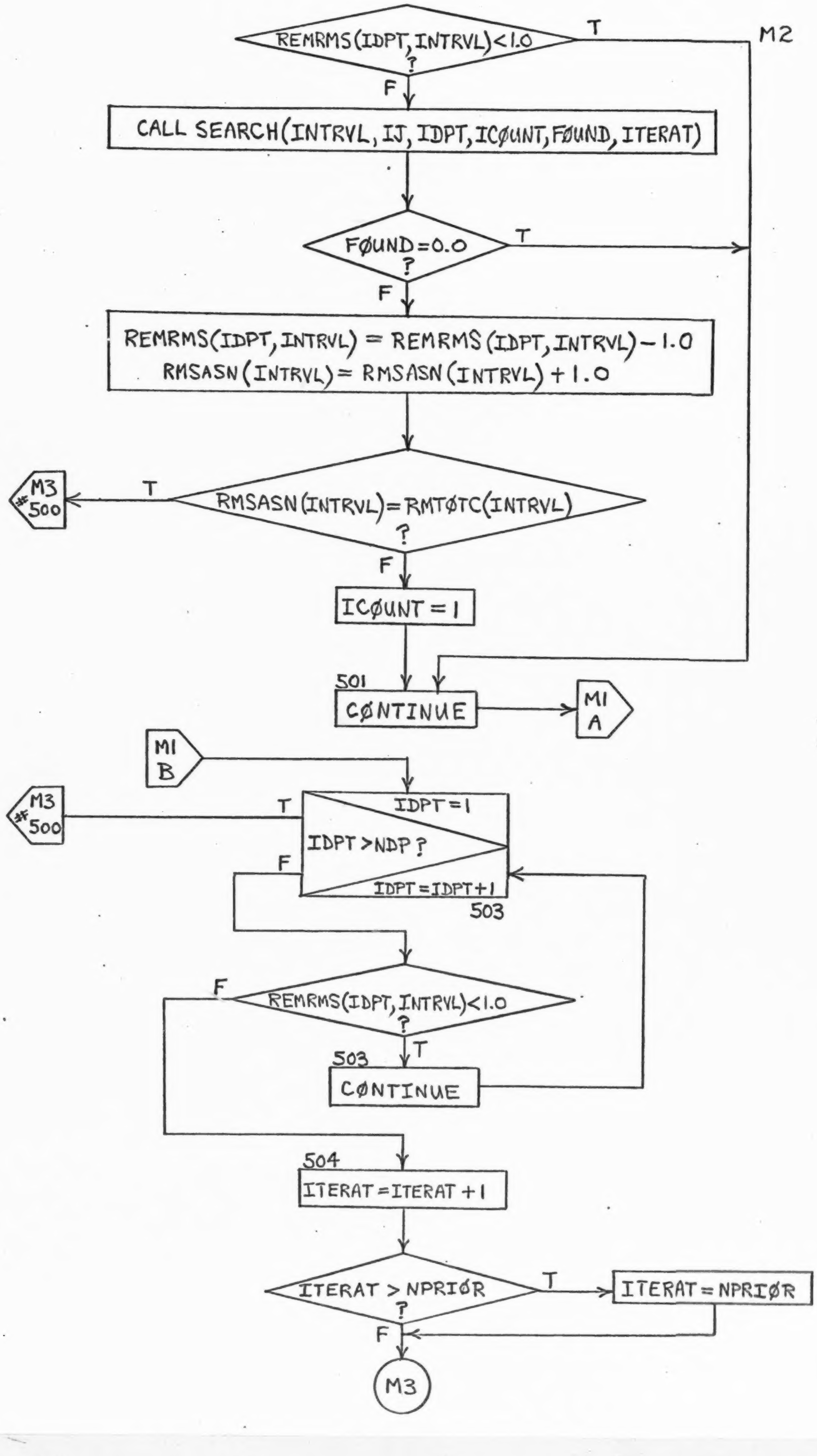
```
      *PORT FOR LECTURE ROOM FACILITIES/,30X,59H========================
      *=================================/,53X,8HTERM  1912,1H-12//,
      *                                         41X,36HLECTURE, SEMINAR, AN
      *D TUTORIAL ROOMS/,41X,36H---------------                       //,
      *5X,14HSIZE(STUDENTS),4X,1H*,4X,21HTOTAL ROOMS AVAILABLE,4X,1H*,
      *4X,31HFORECASTED TOTAL ROOMS REQUIRED,4X,1H*,4X,12HDIFFERENTIAL/,
      *5X,18H---------------- -,1H*,29H----------                  ,
      *1H*,39H------------                -         ,1H*,16H-----------
      *----)
       DO 90 INTRVL=1,NINT1
       IJ=INTRVL+1
       WRITE(6,601)BINT(INTRVL),BINT(IJ),RMTOTD(INTRVL),URMS(INTRVL),
      *DIFFRM(INTRVL)
   601 FORMAT(5X,F5.0,4H TO ,F5.0,4X,1H*,11X,F6.1,12X,1H*,16X,F6.1,17X,
      *1H*,7X,F6.1)
    90 CONTINUE
       WRITE(6,602)
   602 FORMAT(5X,18H---------           ,1H*,29H--------
      *--,1H*,39H----------               ^--          ,1H*,
      *16H----------------)
       WRITE(6,88)UTEAWK,RUTIL,SULOWD
    88 FORMAT(//1X,51HNUMBER OF ROOMS CALCULATED USING A TEACHING WEEK OF
      *F6.1,6H HOURS/1X,33HROOM UTILIZATION PARAMETER SET ATF6.1,
      *8H PERCENT/1X,33HSEAT UTILIZATION PARAMETER SET ATF6.1,
      *8H PERCENT//)
C**********************************************************************
C      IF ROOM REQUIREMENTS IN CERTAIN INTERVALS EXCEED THE NUMBER OF ROOMS
C      AVAILABLE, THIS SECTION EVALUATES THE POSSIBILITY OF SATISFYING A ROOM
C      SHORTAGE BY USING ROOMS OF A LARGER SIZE. THIS RECOGNIZES THE FACT THAT
C      SMALL CLASSES, IF NECESSARY, COULD BE TAUGHT IN A LARGE ROOM BUT WITH A
C      CORRESPONDINGLY LOW SEAT UTILIZATION.
C**********************************************************************
       REACH=0.0
       IC=NINT1
       NINT3=NINT1+1
       DO 610 K=1,NINT1
       IF(DIFFRM(IC))611,609,609
   611 NINT3=NINT3-1
       IF(IC.EQ.NINT3) GO TO 609
       KJ=IC+1
       DO 615  IJ=1,NINT1
       IF(KJ.GT.NINT1) GO TO 609
       IF(DIFFRM(KJ))613,613,614
   614 IF(-DIFFRM(IC)-DIFFRM(KJ))619,619,620
   619 DIFFRM(KJ)=DIFFRM(KJ)+DIFFRM(IC)
       REACH=1.0
       DIFFRM(IC)=0.0
       GO TO 609
   620 DIFFRM(IC)=DIFFRM(IC)+DIFFRM(KJ)
       REACH=1.0
       DIFFRM(KJ)=0.0
   613 KJ=KJ+1
   615 CONTINUE
   609 IC=IC-1
       IF(IC.EQ.0) GO TO 618
   610 CONTINUE
C**********************************************************************
C      PRINT A REPORT OF THE EVALUATION OF SHORTAGES OR SURPLUSES OF ROOMS IN TH
```

```
C     VARIOUS SIZE RANGES. IF THERE IS A SURPLUS OF ROOMS IN EACH SIZE INTERVAL
C     PRINTING OF THE REPORT IS SUPRESSED.
C*****************************************************************************
  618 IF(REACH.EQ.0.0) GO TO 617
      WRITE(6,621)
  621 FORMAT(/1X,117HSINCE SEMINARS, TUTORIALS, AND LECTURES MAY BE HELD
     * IN A LARGER ROOM (WITH A CORRESPONDING DROP IN SEAT UTILIZATION),
     */1X,63H THE ACTUAL OVERAGES OR UNDERAGES BY SIZE RANGE ARE AS FOLL
     *OWS-//)
      WRITE(6,622)
  622 FORMAT(5X,14HSIZE(STUDENTS),5X,28HACTUAL OVERAGES OR UNDERAGES/,
     *5X,14H--------------,5X,28H-------------                )
      DO 91 INTRVL=1,NINT1
      IJ=INTRVL+1
      WRITE(6,623)BINT(INTRVL),BINT(IJ),DIFFRM(INTRVL)
  623 FORMAT(5X,F5.0,4H TO ,F5.0,16X,F6.1)
   91 CONTINUE
C*****************************************************************************
C     PRINT A UNIVERSITY WIDE MATCHING REPORT FOR ROOM-HOURS.
C*****************************************************************************
  617 WRITE(6,624)
  624 FORMAT(/51X,16HTOTAL ROOM-HOURS/51X,16H---------        //,2X,
     *14HSIZE(STUDENTS),1X,1H*,1X,8HREQUIRED,1X,1H*,1X,9HAVAILABLE,1X,
     *1H*,1X,12HDIFFERENTIAL,1X,1H*,1X,11HUTILIZATION,1X,1H*,1X,26HDEV.
     *FROM EXPECTED UTILIZ.,1X,1H*,1X,28HEXPECTED OVERAGE OR UNDERAGE/,
     *2X,15H---------------,1H*,10H----------1H*,11H-----------,1H*,
     *14H--------------,1H*,13H-------------,1H*,28H---------
     *--------,1H*,29H----------          --------   )
      DO 93 INTRVL=1,NINT1
      IJ=INTRVL+1
      WRITE(6,625)BINT(INTRVL),BINT(IJ),TRMHRS(INTRVL),RMHRTO(INTRVL),
     *DIFFHR(INTRVL),HRUTIL(INTRVL),HRDEV(INTRVL),HRLACK(INTRVL)
  625 FORMAT(2X,F5.0,4H TO ,F5.0,1X,1H*,1X,F8.1,1X,1H*,1X,F8.1,2X,1H*,
     *2X,F8.1,4X,1H*,3X,F6.1,4X,1H*,11X,F6.1,11X,1H*,11X,F8.1)
   93 CONTINUE
      WRITE(6,626)
  626 FORMAT(2X,15H----------- -  ,1H*,10H----------,1H*,11H-----------,
     *1H*,14H--------------,1H*,13H-------------,1H*,28H---------------
     *------------,1H*,29H----------^-- -------         )
      WRITE(6,627)RUTIL
  627 FORMAT(/1X,23HEXPECTED UTILIZATION OFF6.1,68H PERCENT IS BASED ON
     *THE SCHEDULING SOPHISTICATION OF THE UNIVERSITY)
      DO 628 INTRVL=1,NINT1
      RMDIFF(ISIMYR,INTRVL)=DIFFRM(INTRVL)
  628 CONTINUE
      RETURN
      END

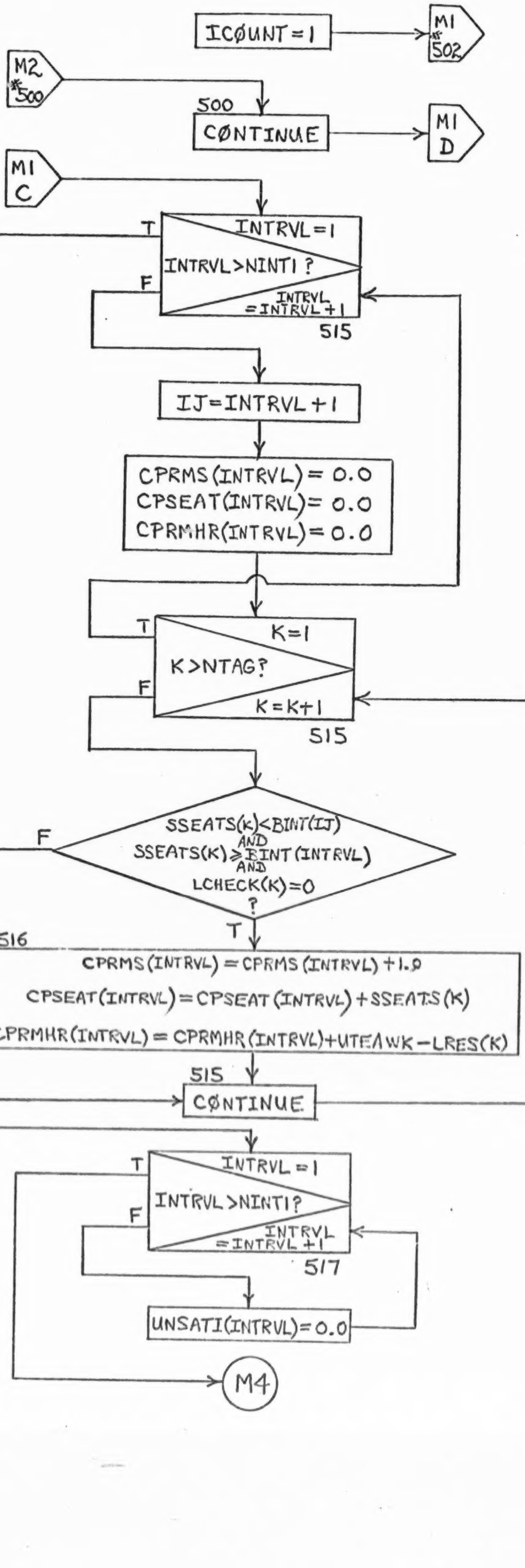
  165*CARDS
```

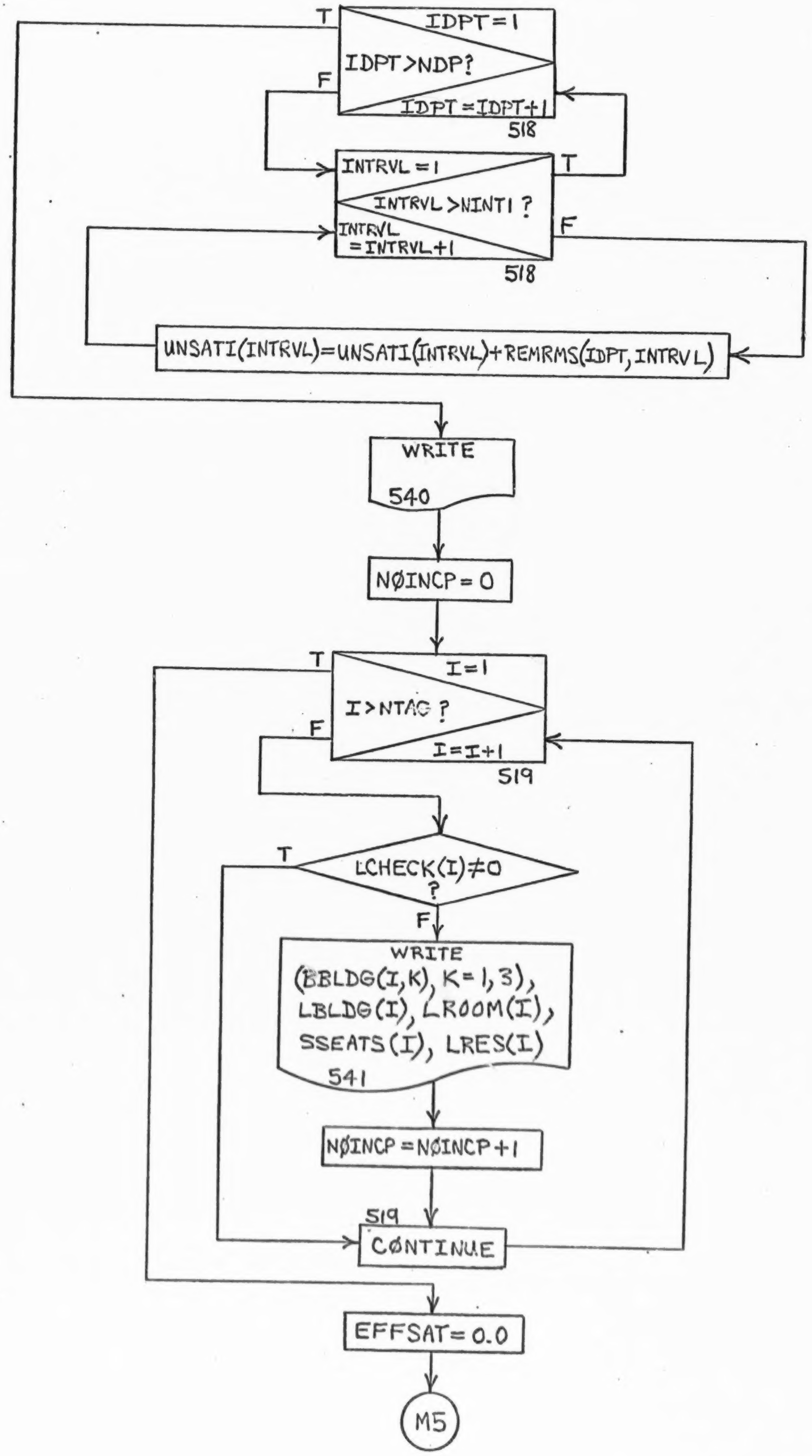

SUBROUTINE
ENTER
MATCH
CALL SEARCH TO MATCH ROOM REQUIREMENTS OF EACH SIZE FOR EACH DEPARTMENT
CONTROL SUCCESSIVE SEARCHING THROUGH EACH DEPARTMENT'S LIST OF BUILDINGS
CALCULATE VARIOUS STATISTICS ON ROOMS REMAINING IN THE CENTRAL ROOM POOL
PRINT CENTRAL ROOM POOL STATISTICAL REPORT
PRINT REPORT OF SEAT UTILIZATIONS COMPUTED DURING THE MATCHING PROCESS
CALCULATE THE EFFICIENCY OF THE MATCHING PROCESS
PRINT MATCHING EFFICIENCY FOR EACH ROOM SIZE INTERVAL
CALCULATE THE PERCENTAGE OF ROOMS MATCHED IN EACH BUILDING
PRINT PERCENTAGE MATCHED
RETURN

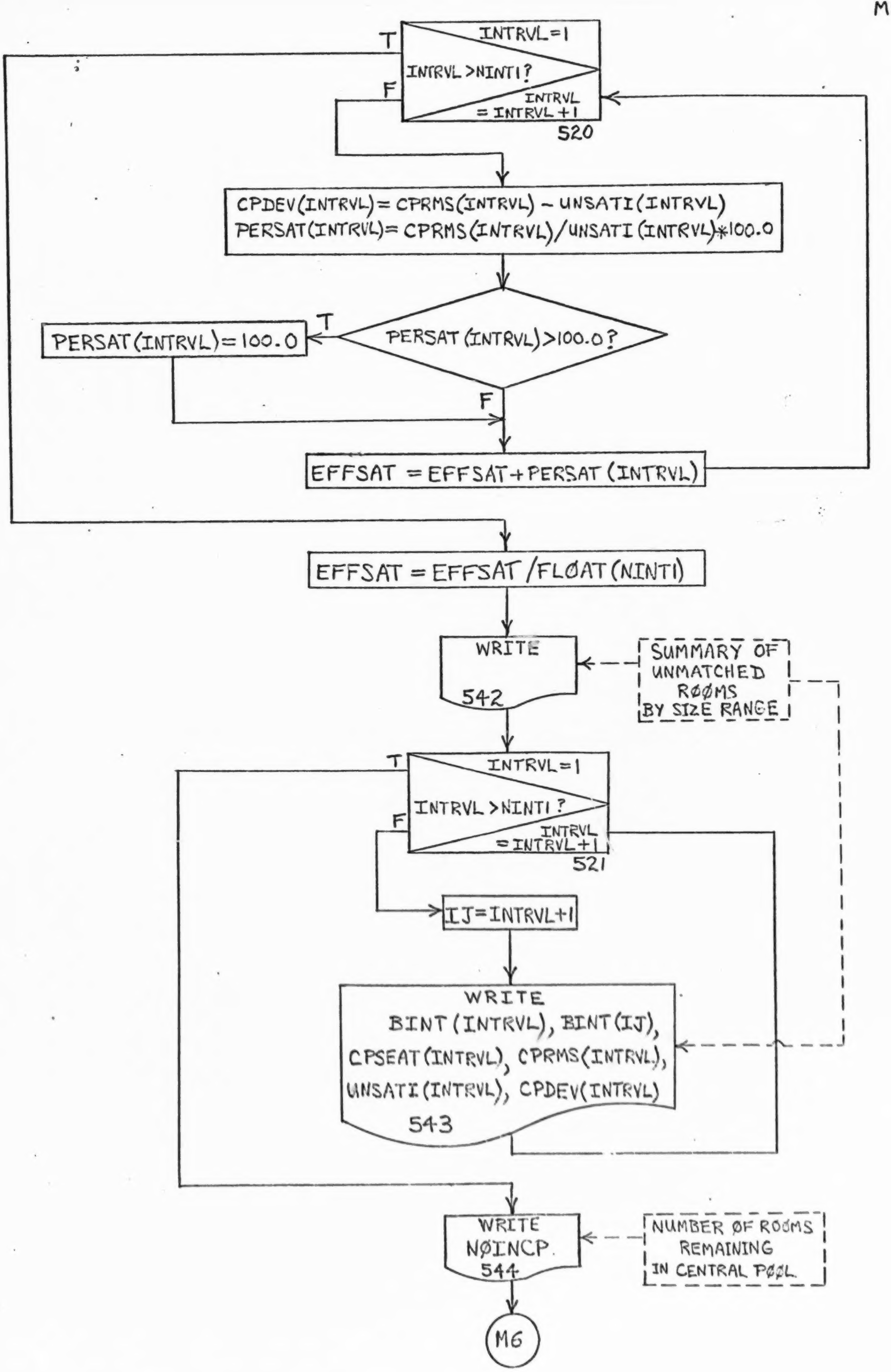

ENTER
T
IDPT=1
IDPT>NDP?
F
IDPT=IDPT+1
510
INTRVL=1
T
INTRVL>NINTI?
F
INTRVL
=INTRVL+1
510
REMRMS(IDPT, INTRVL) = RRØØMS(IDPT, INTRVL)
T
I=1
I>NTAG?
F
I=I+1
511
LCHECK(I)=0
STØREU(I) = 0.0
M3
C
INTRVL=1
INTRVL>NINTI?
INTRVL
= INTRVL+1
500
M3
D
RMSASN(INTRVL)=0.0
ITERAT=1
ICØUNT=1
IJ=INTRVL+1
M3
#502
502
M2
B
T
IDPT=1
IDPT>NDP?
F
IDPT=IDPT+1
501
M2
A
M2

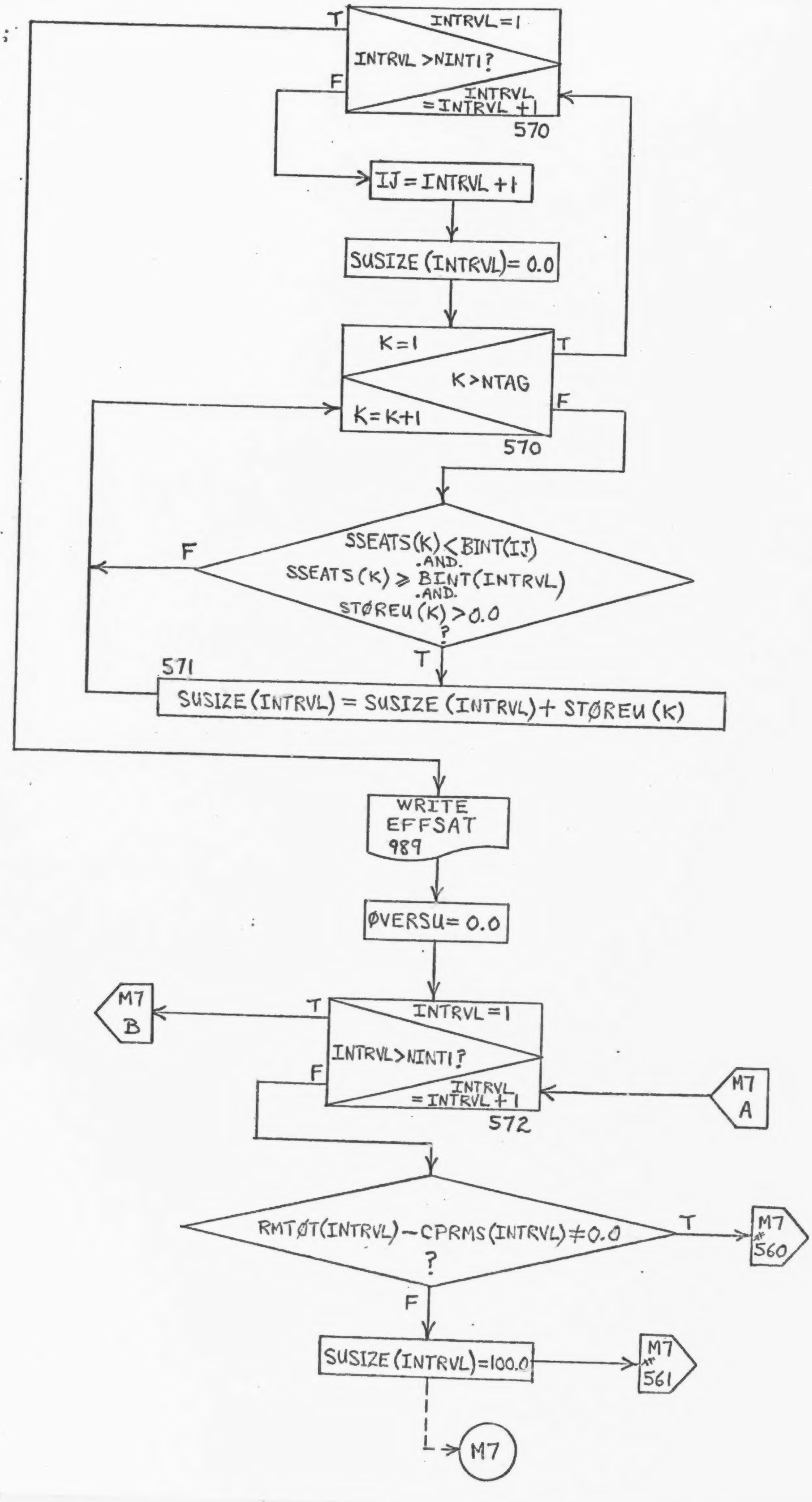

REMRMS(IDPT, INTRVL)<1.0 ?
T
M2
F
CALL SEARCH(INTRVL, IJ, IDPT, ICØUNT, FØUND, ITERAT)
FØUND=0.0 ?
T
F
REMRMS(IDPT, INTRVL) = REMRMS (IDPT, INTRVL) − 1.0
RMSASN (INTRVL) = RMSASN (INTRVL) + 1.0
M3 #500
T
RMSASN (INTRVL) = RMTØTC(INTRVL) ?
F
ICØUNT = 1
501
CØNTINUE
M1 A
M1 B
M3 #500
T
IDPT = 1
IDPT > NDP ?
F
IDPT = IDPT + 1
503
F
REMRMS(IDPT, INTRVL)<1.0 ?
T
503
CØNTINUE
504
ITERAT = ITERAT + 1
ITERAT > NPRIØR ?
T
ITERAT = NPRIØR
F
M3

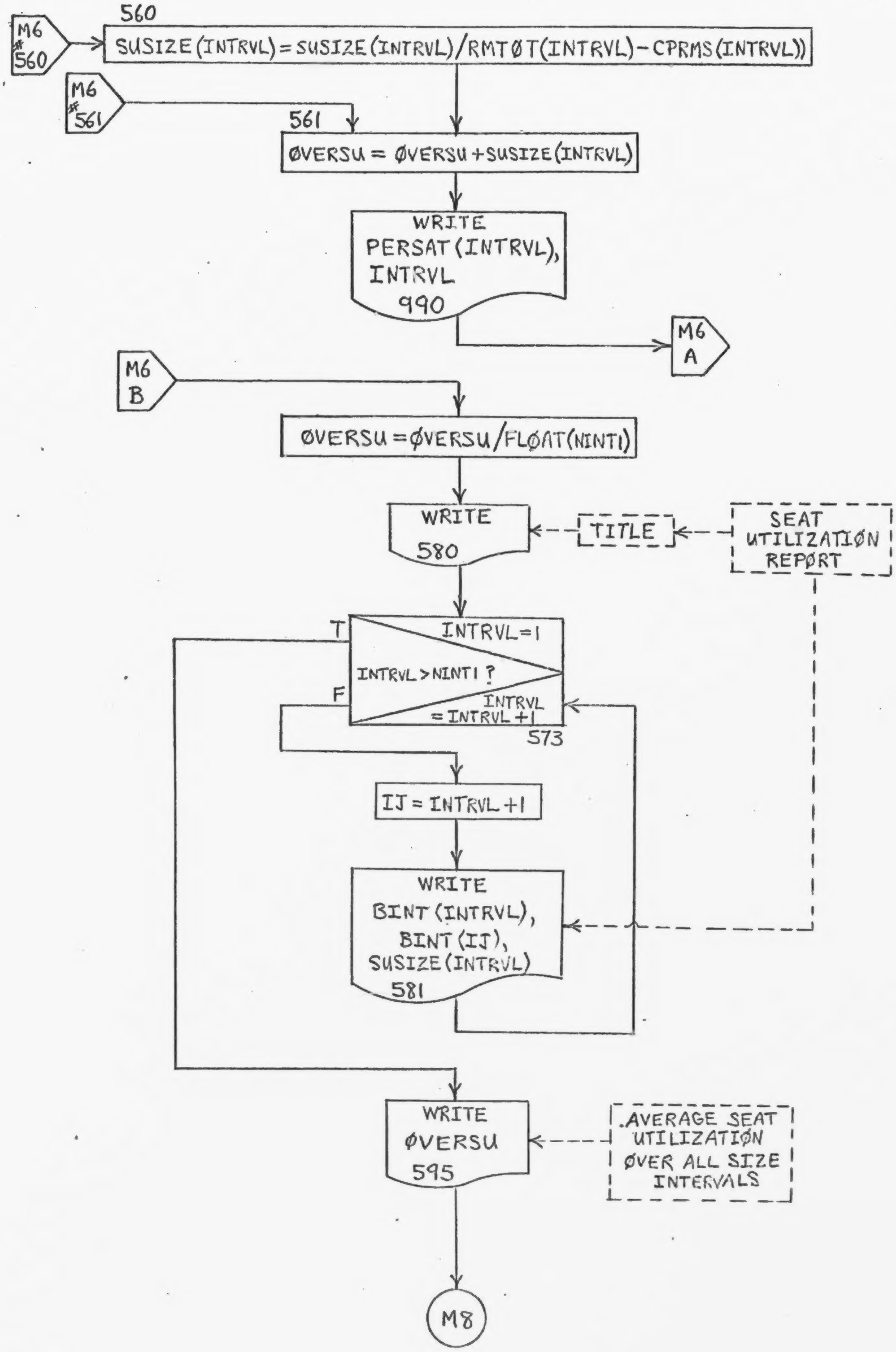
M3

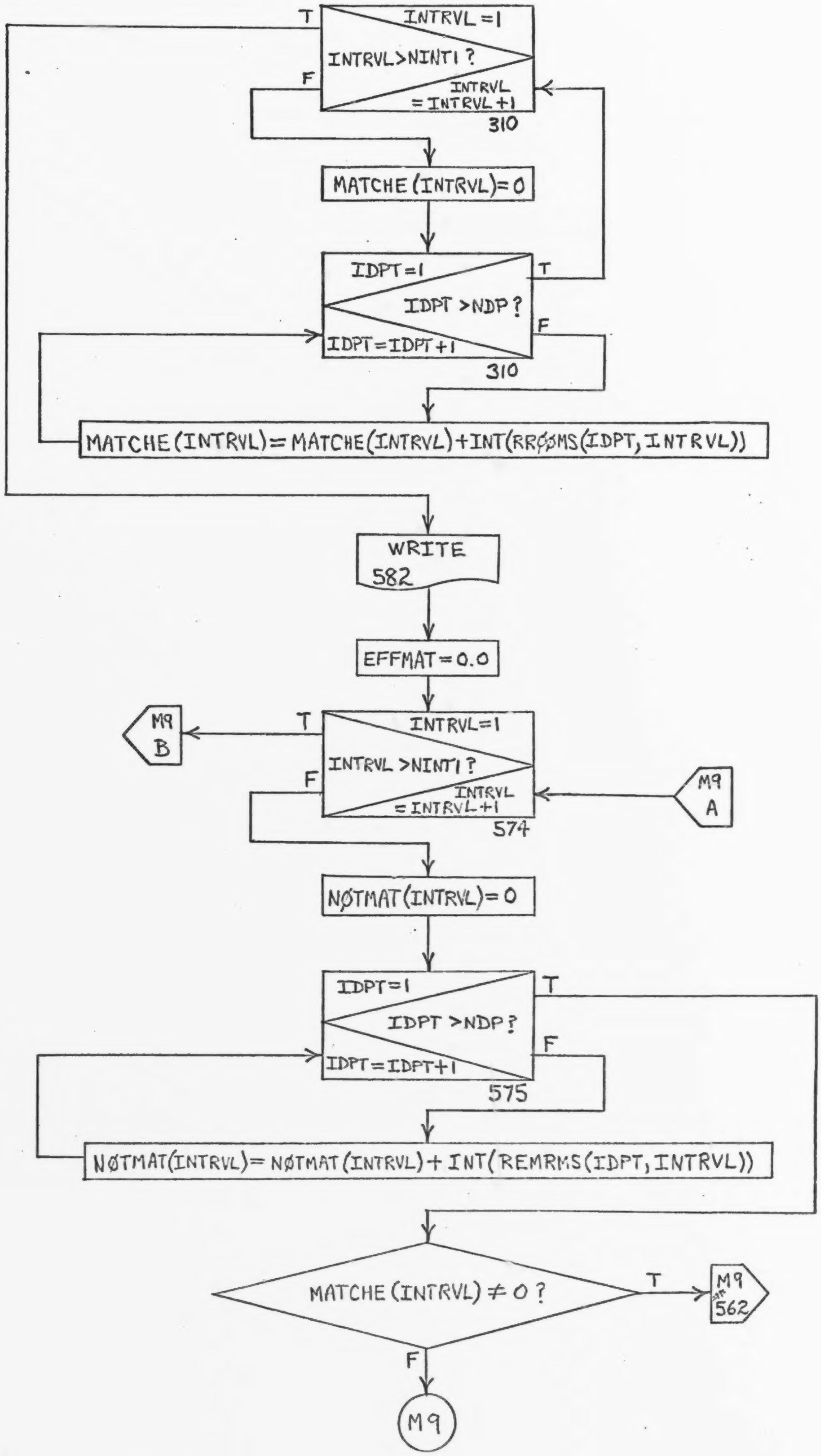

ICØUNT=1
M1 502
M2 500
500
CØNTINUE
M1 D
M1 C
T
INTRVL=1
INTRVL>NINTI ?
F
INTRVL =INTRVL+1
515
IJ=INTRVL+1
CPRMS(INTRVL)= 0.0
CPSEAT(INTRVL)= 0.0
CPRMHR(INTRVL)= 0.0
T
K=1
K>NTAG?
F
K=K+1
515
F
SSEATS(K)<BINT(IJ)
AND
SSEATS(K)≥BINT(INTRVL)
AND
LCHECK(K)=0
?
T
516
CPRMS(INTRVL)=CPRMS(INTRVL)+1.0
CPSEAT(INTRVL)=CPSEAT(INTRVL)+SSEATS(K)
CPRMHR(INTRVL)=CPRMHR(INTRVL)+UTEAWK−LRES(K)
515
CØNTINUE
T
INTRVL=1
INTRVL>NINTI?
F
INTRVL =INTRVL+1
517
UNSATI(INTRVL)=0.0
M4

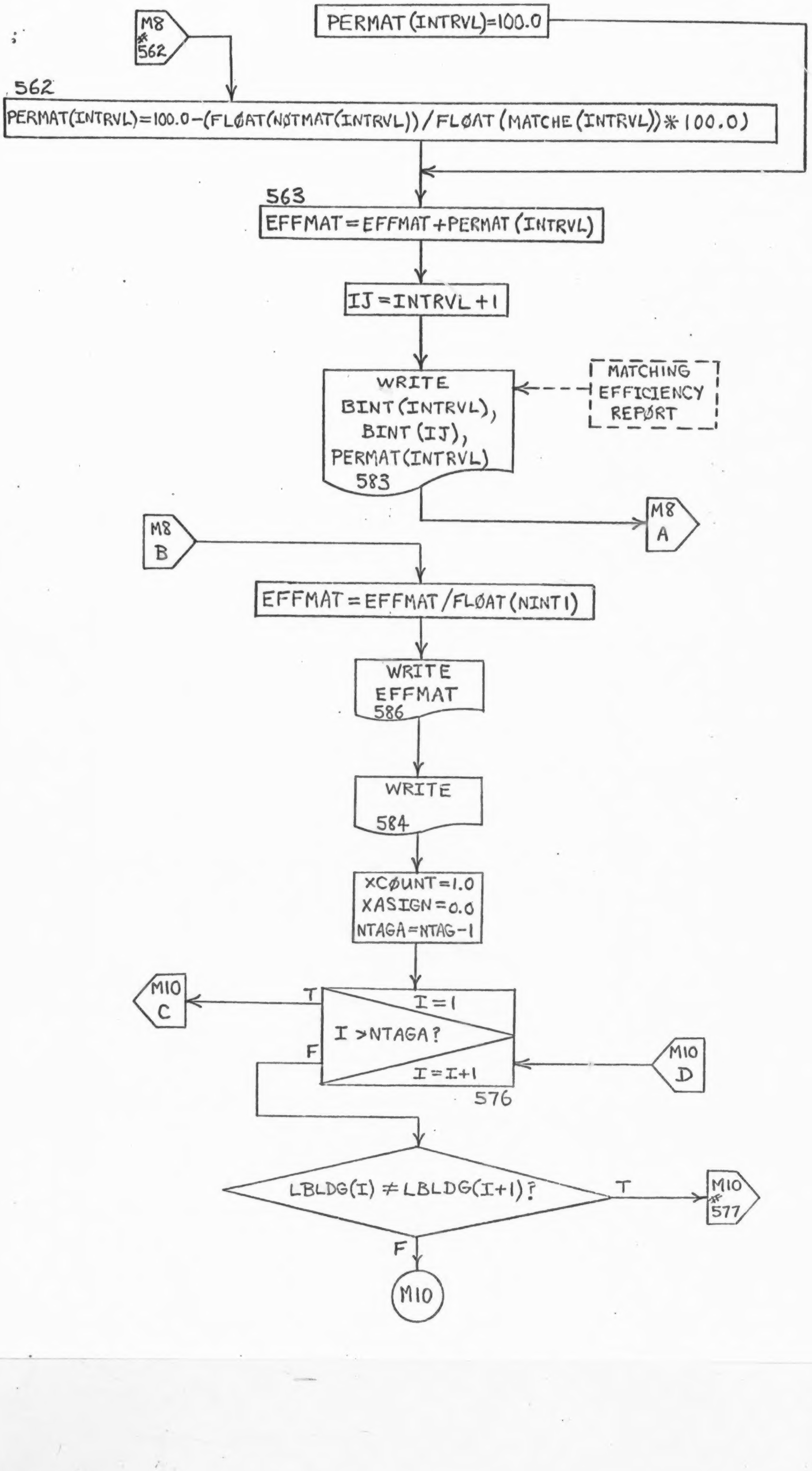

T
IDPT=1
IDPT>NDP?
F
IDPT=IDPT+1
518
INTRVL=1
T
INTRVL>NINT1 ?
F
INTRVL
=INTRVL+1
518
UNSATI(INTRVL)=UNSATI(INTRVL)+REMRMS(IDPT, INTRVL)
WRITE
540
NØINCP=0
T
I=1
I>NTAG ?
F
I=I+1
519
T
LCHECK(I)≠0
?
F
WRITE
(BBLDG(I,K), K=1,3),
LBLDG(I), LROOM(I),
SSEATS(I), LRES(I)
541
NØINCP=NØINCP+1
519
CØNTINUE
EFFSAT=0.0
M5

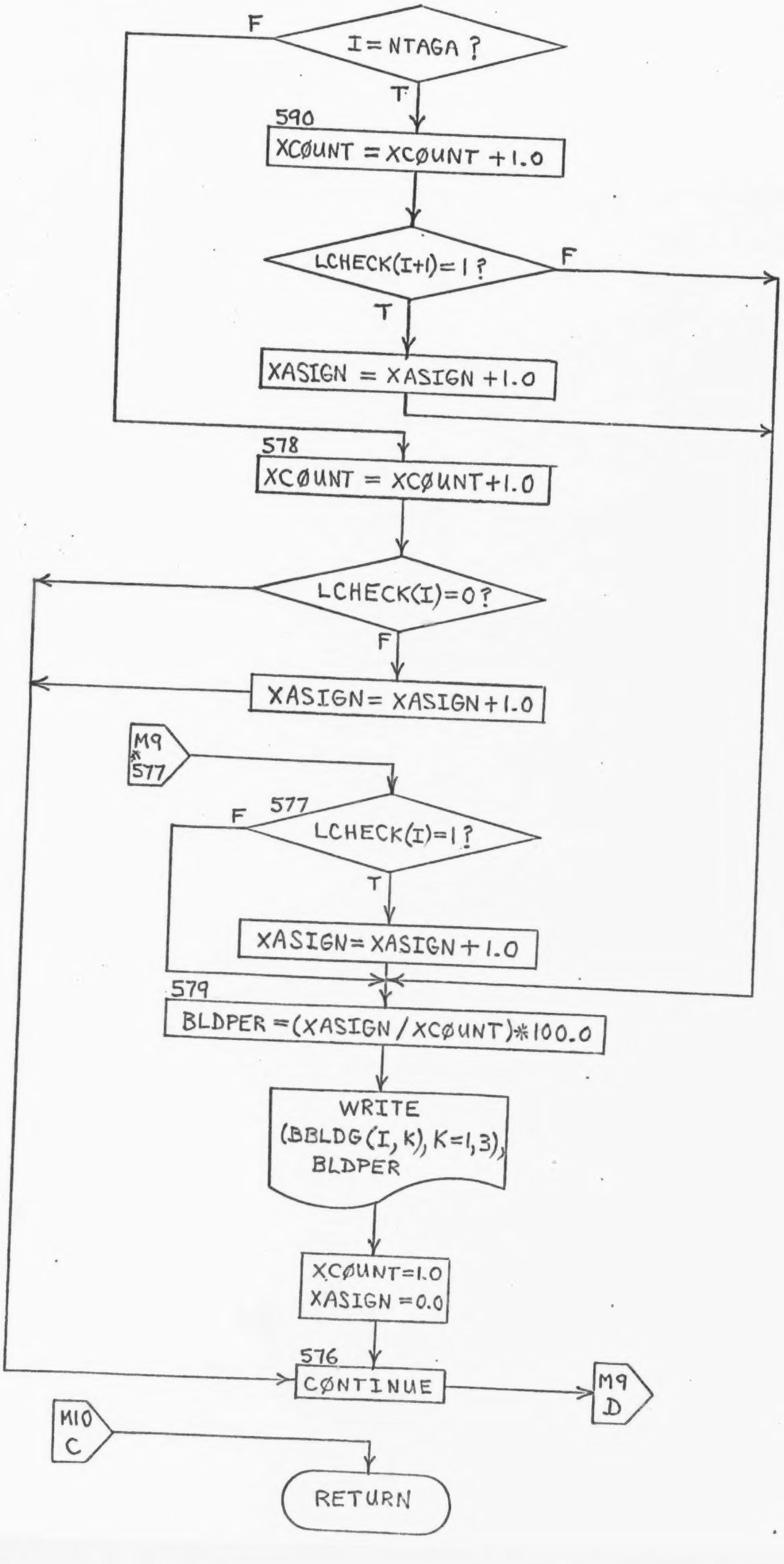

INTRVL=1
INTRVL >NINTI?
INTRVL = INTRVL+1
T
F
520
CPDEV(INTRVL)= CPRMS(INTRVL) - UNSATI(INTRVL)
PERSAT(INTRVL)= CPRMS(INTRVL)/UNSATI(INTRVL)*100.0
PERSAT(INTRVL)>100.0?
T
PERSAT(INTRVL)=100.0
F
EFFSAT = EFFSAT+PERSAT(INTRVL)
EFFSAT = EFFSAT/FLØAT(NINTI)
WRITE
542
SUMMARY OF UNMATCHED RØØMS BY SIZE RANGE
INTRVL=1
INTRVL >NINTI?
INTRVL = INTRVL+1
T
F
521
IJ=INTRVL+1
WRITE
BINT(INTRVL), BINT(IJ),
CPSEAT(INTRVL), CPRMS(INTRVL),
UNSATI(INTRVL), CPDEV(INTRVL)
543
WRITE
NØINCP
544
NUMBER ØF RØØMS REMAINING IN CENTRAL PØØL
M6


T
INTRVL=1
INTRVL >NINT1?
F
INTRVL =INTRVL +1
570
IJ = INTRVL +1
SUSIZE (INTRVL)= 0.0
K=1
T
K>NTAG
F
K=K+1
570
SSEATS(K)<BINT(IJ) .AND. SSEATS(K) ≥ BINT(INTRVL) .AND. STØREU(K) >0.0 ?
F
T
571
SUSIZE (INTRVL) = SUSIZE (INTRVL)+ STØREU (K)
WRITE EFFSAT 989
ØVERSU= 0.0
M7 B
T
INTRVL=1
INTRVL>NINT1?
F
INTRVL =INTRVL+1
572
M7 A
RMTØT(INTRVL)-CPRMS(INTRVL)≠0.0 ?
T
M7 # 560
F
SUSIZE (INTRVL)=100.0
M7 # 561
M7


M6 # 560
560
SUSIZE(INTRVL)=SUSIZE(INTRVL)/RMTØT(INTRVL)-CPRMS(INTRVL))
M6 # 561
561
ØVERSU = ØVERSU +SUSIZE(INTRVL)
WRITE PERSAT(INTRVL), INTRVL
990
M6 A
M6 B
ØVERSU=ØVERSU/FLØAT(NINTI)
WRITE
580
TITLE
SEAT UTILIZATIØN REPØRT
T
F
INTRVL=1
INTRVL>NINTI ?
INTRVL =INTRVL+1
573
IJ = INTRVL+1
WRITE BINT(INTRVL), BINT(IJ), SUSIZE(INTRVL)
581
WRITE ØVERSU
595
AVERAGE SEAT UTILIZATIØN ØVER ALL SIZE INTERVALS
M8


T
INTRVL=1
INTRVL>NINT1 ?
F
INTRVL
=INTRVL+1
310
MATCHE(INTRVL)=0
IDPT=1
T
IDPT >NDP ?
F
IDPT=IDPT+1
310
MATCHE(INTRVL)=MATCHE(INTRVL)+INT(RRØØMS(IDPT,INTRVL))
WRITE
582
EFFMAT=0.0
M9
B
T
INTRVL=1
INTRVL >NINT1 ?
F
INTRVL
=INTRVL+1
574
M9
A
NØTMAT(INTRVL)=0
IDPT=1
T
IDPT >NDP ?
F
IDPT=IDPT+1
575
NØTMAT(INTRVL)=NØTMAT(INTRVL)+INT(REMRMS(IDPT,INTRVL))
MATCHE(INTRVL) ≠ 0 ?
T
M9
562
F
M9

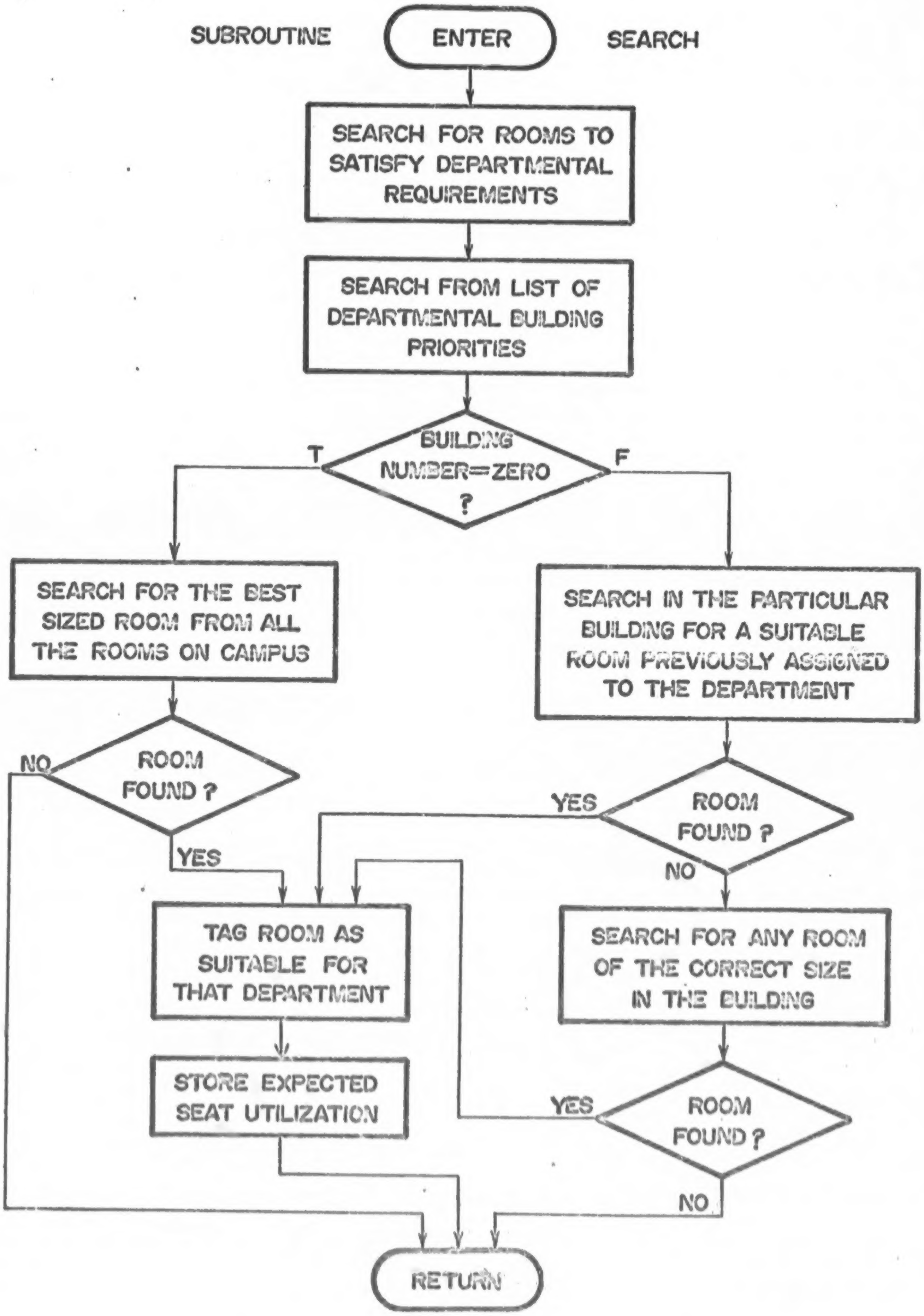

M8
#
562
PERMAT(INTRVL)=100.0
562
PERMAT(INTRVL)=100.0-(FLØAT(NØTMAT(INTRVL))/FLØAT(MATCHE(INTRVL))*100.0)
563
EFFMAT=EFFMAT+PERMAT(INTRVL)
IJ=INTRVL+1
WRITE
BINT(INTRVL),
BINT(IJ),
PERMAT(INTRVL)
583
MATCHING
EFFICIENCY
REPØRT
M8
A
M8
B
EFFMAT=EFFMAT/FLØAT(NINT1)
WRITE
EFFMAT
586
WRITE
584
XCØUNT=1.0
XASIGN=0.0
NTAGA=NTAG-1
M10
C
T
I=1
I >NTAGA?
F
I=I+1
576
M10
D
LBLDG(I) ≠ LBLDG(I+1)?
T
M10
#
577
F
M10

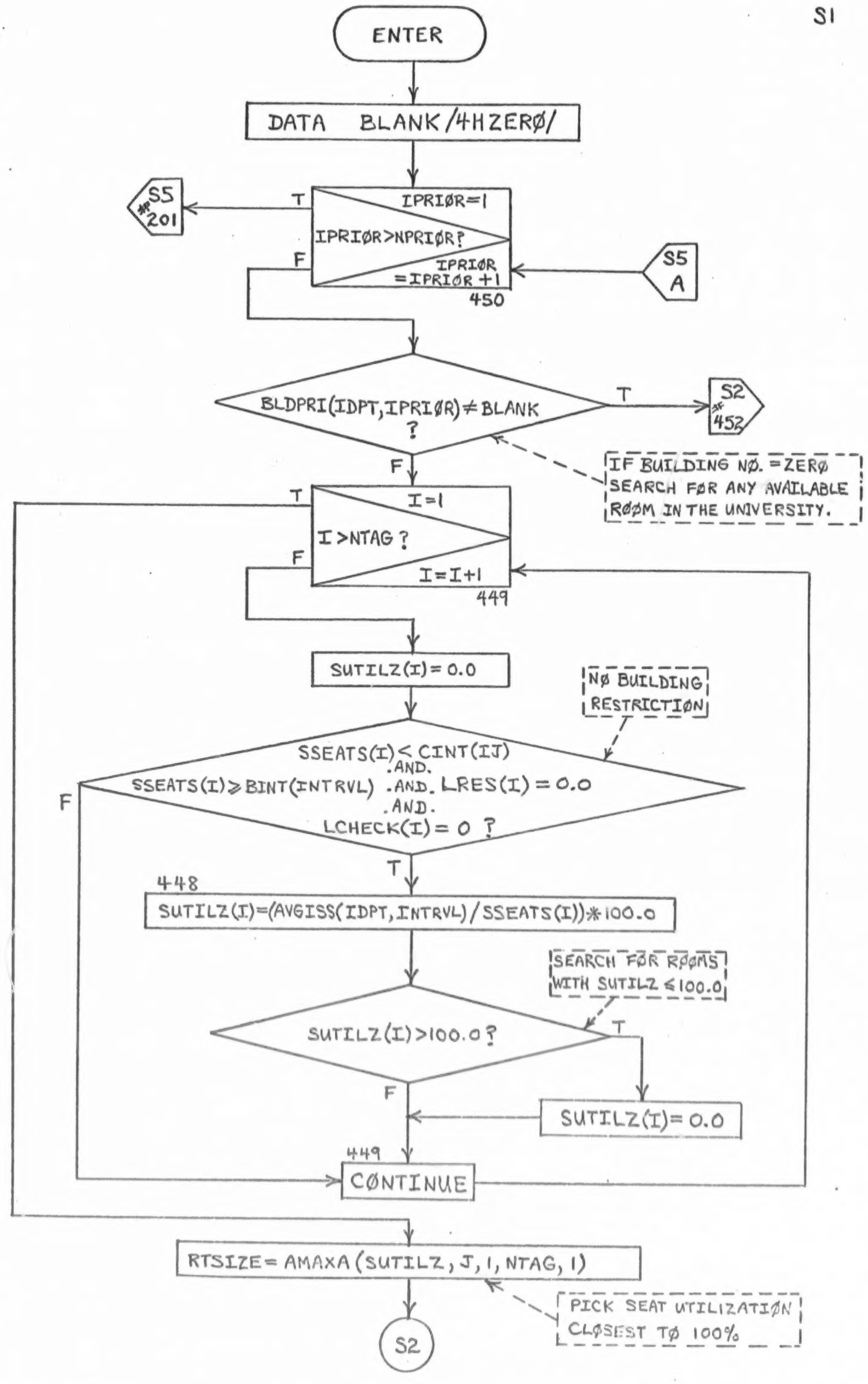

I = NTAGA ?
F
T
590
XCØUNT = XCØUNT + 1.0
LCHECK(I+1) = 1 ?
F
T
XASIGN = XASIGN + 1.0
578
XCØUNT = XCØUNT + 1.0
LCHECK(I) = 0 ?
F
XASIGN = XASIGN + 1.0
M9
577
577
F
LCHECK(I) = 1 ?
T
XASIGN = XASIGN + 1.0
579
BLDPER = (XASIGN / XCØUNT) * 100.0
WRITE
(BBLDG(I, K), K=1, 3),
BLDPER
XCØUNT = 1.0
XASIGN = 0.0
576
CØNTINUE
M9
D
M10
C
RETURN

```
C*******************************************************************************
C     SUBROUTINE MATCH.  A ROUTINE TO MATCH DEPARTMENTAL ROOM REQUIREMENTS
C     AGAINST SPACE AVAILABLE TO THAT DEPARTMENT ON CAMPUS. THE SUBROUTINE CALLS
C     SUBROUTINE SEARCH TO EVALUATE IF THE CORRECT SIZE AND TYPE OF SPACE IS
C     PROVIDED IN A DEPARTMENT,S HOME BUILDING OR A NEIGHBOURING BUILDING.
C     THE ROOMS LEFT IN THE CENTRAL ROOM POOL AFTER MATCHING, THE UNSATISFIED
C     ROOM REQUIREMENTS AFTER MATCHING, EXPECTED SEAT UTILIZATIONS FOR MATCHED
C     ROOMS OF EACH SIZE, THE EFFICIENCY OF THE MATCHING PROCESS, AND THE
C     PERCENTAGE OF ROOMS MATCHED IN EACH BUILDING ARE REPORTED.
C*******************************************************************************
      SUBROUTINE MATCH
      COMMON BLDG(250,3),NBLDG(250),NROOM(250),CCOST(7),   SEATS(250),
     *NODEPT(250),NRES(250),NUPDTE(250),SQFT(250),SQPERS(250),
     *DEVIAT(250),BBLDG(250,3),LBLDG(250),LROOM(250),ROMEAN(7),
     *SSEATS(250),LODEPT(250),LRES(250),LUPDTE(250),SSQFT(250),
     *NCHECK(250),LCHECK(250),RMTOT(7),SEATOT(7),RMHRTO(7),RMHRS(100,7),
     *ITEST(100,9),ROLEES(100,9),STR(100,9),HL(100,9),ROMHRS(100,9),
     *FACHRS(20,7),AMTOFF(100),ROLEED(250,7),DIST(250,7),BINT(8),
     *FACRMS(20,7),AMIDPT(7),URMS(7),DPNAME(100,4),TRMHRS(7),NDIST,NDP,
     *IACA,NINT1,UTEAWK,SUTIL,RUTIL,NTOTAL,NTAG,INIT1,STOREU(250),
     *DRUTIL(100),TEAWK(100),ASSIGN(100)   ,BLDPRI(100,5),AVGISS(100,7),
     *REMRMS(100,7),RROOMS(100,7),SUTILZ(250),           NPRIOR,
     *RMSASN(7),DIFFHR(7),DIFFRM(7),HRUTIL(7),HRDEV(7),HRLACK(7)
     *,CINT(8),SQFTOT(7),RMTOTC(7),AVGINT(7), SIMYR,CPRMS(7),CPSEAT(7),
     *CPRMHR(7),UNSATI(7),CPDEV(7),SUSIZE(7),NDPFAC(20),NFAC(250),
     *LFAC(250),FACNAM(20,4),MATCHE(7),NOTMAT(7),PERMAT(7),NFACUL,
     *EFFMAT,EFFSAT,SUMMAX(20),PERSAT(7),RMDIFF(10,7),SKIP,SSTOP,IEND,
     *IBEGIN,COSTIN,COSTOT,ISIMYR,ROUND,MROUND,SULOW,BLDPER,CSQFT(7),
     *NINT2,OVERSU,DINT(8),RMTOTD(7),SULOWD,THIS
      REAL NRES,LRES,NBLDG,LBLDG,NROOM,LROOM
C*******************************************************************************
C     CREATE AN ARRAY DENOTING THE DEPARTMENTAL UNSATISFIED ROOM REQUIREMENTS.
C     SET EACH ROOM,S CHECK BIT AND STORED SEAT UTILIZATION TO ZERO.
C*******************************************************************************
      DO 510 IDPT=1,NDP
      DO 510 INTRVL=1,NINT1
      REMRMS(IDPT,INTRVL)=RROOMS(IDPT,INTRVL)
  510 CONTINUE
      DO  511 I=1,NTAG
      LCHECK(I)=0
      STOREU(I)=0.0
  511 CONTINUE
C*******************************************************************************
C     INITIALIZE ITERAT= THE NUMBER OF COMPLETE ITERATIONS THROUGH ALL
C                        DEPARTMENTS
C                ICOUNT= THE NUMBER OF ITERATIONS OF SEARCHING FOR A GIVEN
C                        DEPARTMENT
C*******************************************************************************
      DO 500 INTRVL=1,NINT1
      RMSASN(INTRVL)=0.0
      ITERAT=1
      ICOUNT=1
      IJ=INTRVL+1
C*******************************************************************************
C     ONLY A WHOLE NUMBER OF ROOMS WILL BE MATCHED. CHECK TO SEE IF THE NUMBER
C     OF REMAINING ROOMS(REMRMS) IS LESS THAN ONE. IF SO, GO TO THE NEXT
C     DEPARTMENT. OTHERWISE, SEARCH FOR A ROOM. IF A ROOM IS FOUND, REDUCE THE
C     DEPARTMENTAL ROOM REQUIREMENTS BY ONE AND ADD ONE TO THE NUMBER OF ROOMS
C     ASSIGNED IN AN INTERVAL. IF NO ROOM IS FOUND, GO TO THE NEXT DEPARTMENT.
C     THE SUBROUTINE MATCHES ROOMS ONE INTERVAL AT A TIME, SWITCHING TO THE
```

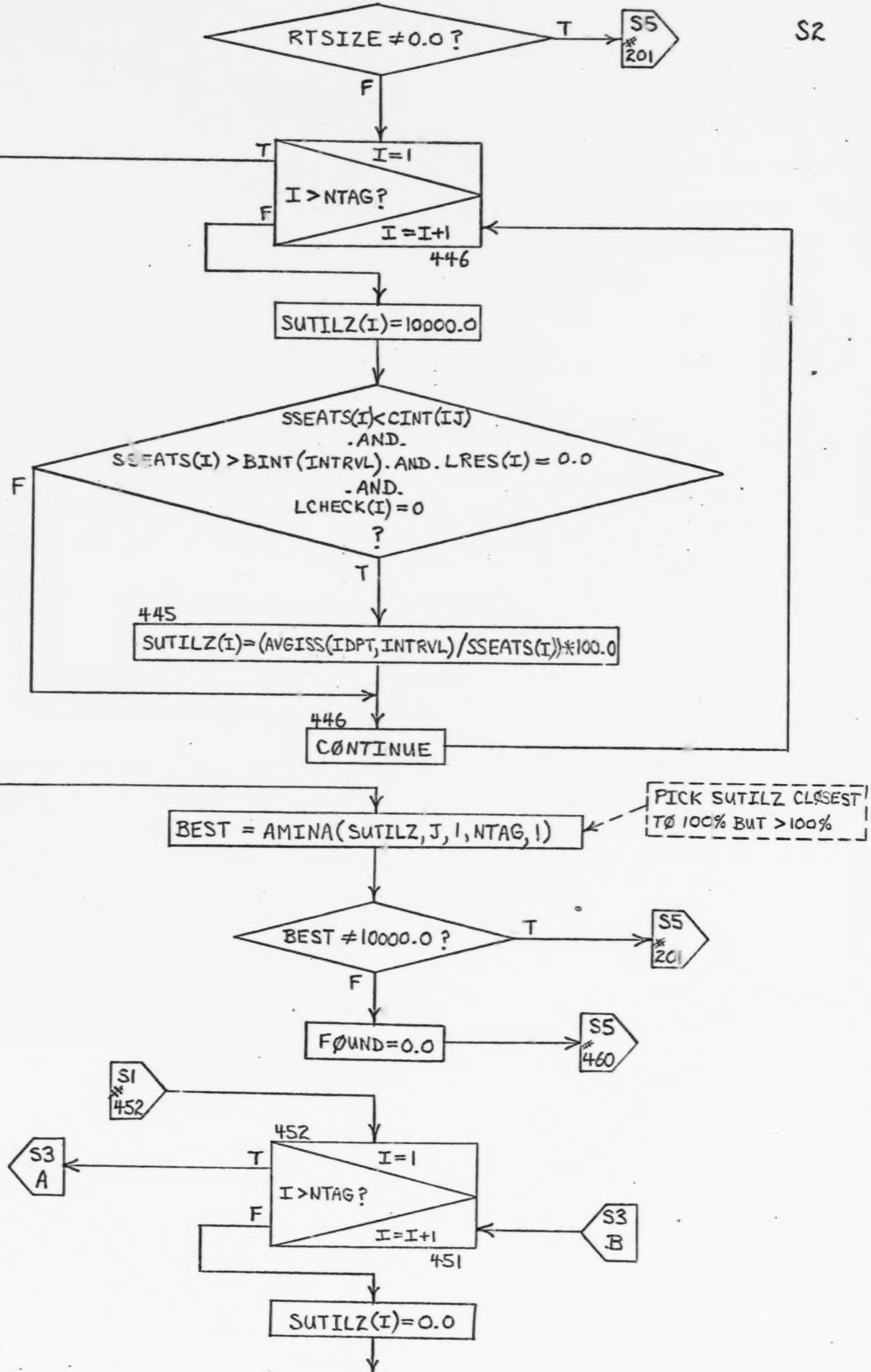
```
C      NEXT INTERVAL IF ALL DEPARTMENTAL REQUIREMENTS IN THAT INTERVAL ARE
C      SATISFIED, OR ALL AVAILABLE ROOMS IN AN INTERVAL ARE ASSIGNED, OR THE
C      NUMBER OF SEARCHING ITERATIONS IS GREATER THAN NPRIOR.
C*******************************************************************************
  502 DO 501 IDPT=1,NDP
      IF(REMRMS(IDPT,INTRVL).LT.1.0) GO TO 501
      CALL SEARCH(INTRVL,IJ,IDPT,ICOUNT,FOUND,ITERAT)
      IF(FOUND.EQ.0.0) GO TO 501
      REMRMS(IDPT,INTRVL)=REMRMS(IDPT,INTRVL)-1.0
      RMSASN(INTRVL)=RMSASN(INTRVL)+1.0
      IF(RMSASN(INTRVL).EQ.RMTOTC(INTRVL)) GO TO 500
      ICOUNT=1
  501 CONTINUE
      DO 503 IDPT=1,NDP
      IF(REMRMS(IDPT,INTRVL).LT.1.0) GO TO 503
      GO TO 504
  503 CONTINUE
      GO TO 500
  504 ITERAT=ITERAT+1
      IF(ITERAT.GT.NPRIOR)GO TO 500
      ICOUNT=1
      GO TO 502
  500 CONTINUE
C*******************************************************************************
C      PRINT A LISTING OF THE ROOMS REMAINING IN THE CENTRAL ROOM POOL AFTER
C      MATCHING AND THE FOLLOWING INFORMATION -
C      CPRMS = THE NUMBER OF ROOMS BY SIZE INTERVAL IN THE CENTRAL ROOM POOL
C      CPSEAT= THE NUMBER OF SEATS BY SIZE INTERVAL IN THE CENTRAL ROOM POOL
C      CPRMHR= THE NUMBER OF ROOM-HOURS BY SIZE INTERVAL IN THE CENTRAL ROOM POOL
C      UNSATI= THE TOTAL UNSATISFIED ROOM REQUIREMENTS BY SIZE INTERVAL(INCLUDES
C              FRACTIONAL ROOM REQUIREMENTS AND UNMATCHED ROOMS)
C      NOINCP= THE NUMBER OF ROOMS IN THE CENTRAL ROOM POOL
C      CPDEV = THE DIFFERENCE BETWEEN CPRMS AND UNSATI
C*******************************************************************************
      DO 515 INTRVL=1,NINT1
      IJ=INTRVL+1
      CPRMS(INTRVL)=0.0
      CPSEAT(INTRVL)=0.0
      CPRMHR(INTRVL)=0.0
      DO 515 K=1,NTAG
      IF(SSEATS(K).LT.BINT(IJ).AND.SSEATS(K).GE.BINT(INTRVL).AND.
     *LCHECK(K).EQ.0) GO TO 516
      GO TO 515
  516 CPRMS(INTRVL)=CPRMS(INTRVL)+1.0
      CPSEAT(INTRVL)=CPSEAT(INTRVL)+SSEATS(K)
      CPRMHR(INTRVL)=CPRMHR(INTRVL)+UTEAWK-LRES(K)
  515 CONTINUE
      DO 517 INTRVL=1,NINT1
      UNSATI(INTRVL)=0.0
  517 CONTINUE
      DO 518 IDPT=1,NDP
      DO 518 INTRVL=1,NINT1
      UNSATI(INTRVL)=UNSATI(INTRVL)+REMRMS(IDPT,INTRVL)
  518 CONTINUE
      WRITE(6,540)
  540 FORMAT(1H1,30X,63HLECTURE ROOMS REMAINING IN THE CENTRAL ROOM POOL
     * AFTER MATCHING/,31X,63H---------------
     *----------------------//,30X,13HBUILDING NAME,4X,9HBLDG. NO.,3X,
     *8HROOM NO.,3X,5HSEATS,3X,16HRESTRICTED HOURS/,30X,13H-------------
     *,4X,9H------    ,3X,8H--------,3X,5H-----,3X,16H----------       )
      NOINCP=0
      DO 519 I=1,NTAG
      IF(LCHECK(I).NE.0) GO TO 519
      WRITE(6,541)(BBLDG(I,K),K=1,3),LBLDG(I),LROOM(I),SSEATS(I),LRES(I)
  541 FORMAT(28X,3A6,4X,A4,5X,A6,5X,F5.0,9X,F4.0)
      NOINCP=NOINCP+1
  519 CONTINUE
      EFFSAT=0.0
      DO 520 INTRVL=1,NINT1
      CPDEV(INTRVL)=CPRMS(INTRVL)-UNSATI(INTRVL)
C*******************************************************************
C     CALCULATE THE PERCENTAGE OF UNSATISFIED ROOM REQUIREMENTS THAT CAN BE
C     SATISFIED BY ROOMS LEFT IN THE CENTRAL ROOM POOL.
C     EFFSAT REPRESENTS THE AVERAGE OF THIS PERCENTAGE SATISFACTION OVER ALL
C     SIZE INTERVALS.
C*******************************************************************
      PERSAT(INTRVL)=CPRMS(INTRVL)/UNSATI(INTRVL)*100.0
      IF(PERSAT(INTRVL).GT.100.0)PERSAT(INTRVL)=100.0
      EFFSAT=EFFSAT+PERSAT(INTRVL)
  520 CONTINUE
      EFFSAT=EFFSAT/FLOAT(NINT1)
      WRITE(6,542)
  542 FORMAT(///,47X,23HBREAKDOWN BY SIZE RANGE/,47X,23H-----------------
     *-------//,5X,14HSIZE(STUDENTS),5X,12HNO. OF SEATS,5X,22HNO. OF ROO
     *MS REMAINING,5X,27HTOTAL UNSATISFIED ROOM REQ.,5X,12HDIFFERENTIAL/
     */)
      DO 521 INTRVL=1,NINT1
      IJ=INTRVL+1
      WRITE(6,543)BINT(INTRVL),BINT(IJ),CPSEAT(INTRVL),CPRMS(INTRVL),
     *UNSATI(INTRVL),CPDEV(INTRVL)
  543 FORMAT(5X,F5.0,4H TO ,F5.0,8X,F6.0,16X,F6.1,25X,F6.1,19X,F6.1)
  521 CONTINUE
      WRITE(6,544)NOINCP
  544 FORMAT(49X,6H------/,43X,5HTOTAL,2X,I3)
C*******************************************************************
C     THIS SECTION CALCULATES AND REPORTS THE AVERAGE SEAT UTILIZATION BY SIZE
C     INTERVAL(SUSIZE) FOR MATCHED ROOMS AFTER THE MATCHING PROCESS.
C     OVERSU= THE AVERAGE SEAT UTILIZATION OVER ALL SIZE INTERVALS
C*******************************************************************
      DO 570 INTRVL=1,NINT1
      IJ=INTRVL+1
      SUSIZE(INTRVL)=0.0
      DO 570 K=1,NTAG
      IF(SSEATS(K).LT.BINT(IJ).AND.SSEATS(K).GE.BINT(INTRVL).AND.
     *STOREU(K).GT.0.0) GO TO 571
      GO TO 570
  571 SUSIZE(INTRVL)=SUSIZE(INTRVL)+STOREU(K)
  570 CONTINUE
      WRITE(6,989)EFFSAT
  989 FORMAT(1H1,7HEFFSAT=F6.1,//)
      OVERSU=0.0
      DO 572 INTRVL=1,NINT1
      IF(RMTOT(INTRVL)-CPRMS(INTRVL).NE.0.0) GO TO 560
      SUSIZE(INTRVL)=100.0
      GO TO 561
  560 SUSIZE(INTRVL)=SUSIZE(INTRVL)/(RMTOT(INTRVL)-CPRMS(INTRVL))
  561 OVERSU=OVERSU+SUSIZE(INTRVL)
      WRITE(6,990)PERSAT(INTRVL),INTRVL
  990 FORMAT(1X,7HPERSAT=F6.1,2X,9HINTERVAL=I2)
  572 CONTINUE
      OVERSU=OVERSU/FLOAT(NINT1)
      WRITE(6,580)
  580 FORMAT(1H1,20X,69HAVERAGE SEAT UTILIZATION FOR ROOMS ASSIGNED TO I
     *NDIVIDUAL DEPARTMENTS//,35X,14HSIZE(STUDENTS),10X,16HSEAT UTILIZAT
     *ION//)
      DO 573 INTRVL=1,NINT1
      IJ=INTRVL+1
      WRITE(6,581)BINT(INTRVL),BINT(IJ),SUSIZE(INTRVL)
  581 FORMAT(35X,F5.0,4H TO ,F5.0,14X,F6.1)
  573 CONTINUE
      WRITE(6,595)OVERSU
  595 FORMAT(1H0,36X,26HOVERALL SEAT UTILIZATION =F6.1,8H PERCENT///)
C***********************************************************************
C     MATCHE= THE NUMBER OF ROOMS TO BE MATCHED BY SIZE INTERVAL
C     NOTMAT= THE NUMBER OF UNMATCHED ROOMS BY SIZE INTERVAL
C     CALCULATE THE MATCHING EFFICIENCY BY SIZE INTERVAL = THE NUMBER OF ROOMS
C     MATCHED/THE NUMBER OF ROOMS TO BE MATCHED TIMES 100 PERCENT.
C     EFFMAT= THE AVERAGE MATCHING EFFICIENCY OVER ALL SIZE RANGES
C***********************************************************************
      DO 310 INTRVL=1,NINT1
      MATCHE(INTRVL)=0
      DO 310 IDPT=1,NDP
      MATCHE(INTRVL)=MATCHE(INTRVL)+INT(RROOMS(IDPT,INTRVL))
  310 CONTINUE
      WRITE(6,582)
  582 FORMAT(///5X,110HMATCHING EFFICIENCY BY SIZE INTERVAL = NUMBER OF
     *ROOMS MATCHED/NUMBER OF ROOMS TO BE MATCHED TIMES 100 PERCENT//,
     *35X,14HSIZE(STUDENTS),10X,19HMATCHING EFFICIENCY//)
      EFFMAT=0.0
      DO 574 INTRVL=1,NINT1
      NOTMAT(INTRVL)=0
      DO 575 IDPT=1,NDP
      NOTMAT(INTRVL)=NOTMAT(INTRVL)+INT(REMRMS(IDPT,INTRVL))
  575 CONTINUE
      IF(MATCHE(INTRVL).NE.0) GO TO 562
      PERMAT(INTRVL)=100.0
      GO TO 563
  562 PERMAT(INTRVL)=100.0-(FLOAT(NOTMAT(INTRVL))/FLOAT(MATCHE(INTRVL))*
     *100.0)
  563 EFFMAT=EFFMAT+PERMAT(INTRVL)
      IJ=INTRVL+1
      WRITE(6,583)BINT(INTRVL),BINT(IJ),PERMAT(INTRVL)
  583 FORMAT(35X,F5.0,4H TO ,F5.0,13X,F6.1,8H PERCENT)
  574 CONTINUE
      EFFMAT=EFFMAT/FLOAT(NINT1)
      WRITE(6,586)EFFMAT
  586 FORMAT(1H0,32X,29HOVERALL MATCHING EFFICIENCY =F6.1,8H PERCENT///)
C***********************************************************************
C     THE FOLLOWING STATEMENTS COUNT THE NUMBER OF LECTURE ROOMS IN A BUILDING
C     (XCOUNT) AND THE NUMBER OF ROOMS MATCHED IN A BUILDING(XASIGN). THE
C     PERCENTAGE OF ROOMS MATCHED IN EACH BUILDING(BLDPER) IS THEN CALCULATED
C     AND PRINTED.
C***********************************************************************
      WRITE(6,584)
  584 FORMAT(1H1,31X,44HPERCENTAGE OF ROOMS MATCHED IN EACH BUILDING//,
     *34X,13HBUILDING NAME,10X,18HPERCENTAGE MATCHED//)
      XCOUNT=1.0
      XASIGN=0.0
      NTAGA=NTAG-1
      DO 576 I=1,NTAGA
      IF(LBLDG(I).NE.LBLDG(I+1)) GO TO 577
      IF(I.EQ.NTAGA) GO TO 590
      GO TO 578
  590 XCOUNT=XCOUNT+1.0
      IF(LCHECK(I+1).EQ.1) XASIGN=XASIGN+1.0
      GO TO 579
  578 XCOUNT=XCOUNT+1.0
      IF(LCHECK(I).EQ.0) GO TO 576
      XASIGN=XASIGN+1.0
      GO TO 576
  577 IF(LCHECK(I).EQ.1) XASIGN=XASIGN+1.0
  579 BLDPER=(XASIGN/XCOUNT)*100.0
      WRITE(6,585)(BBLDG(I,K),K=1,3),BLDPER
  585 FORMAT(32X,3A6,12X,F6.1)
      XCOUNT=1.0
      XASIGN=0.0
  576 CONTINUE
      RETURN
      END

   259*CARDS
```

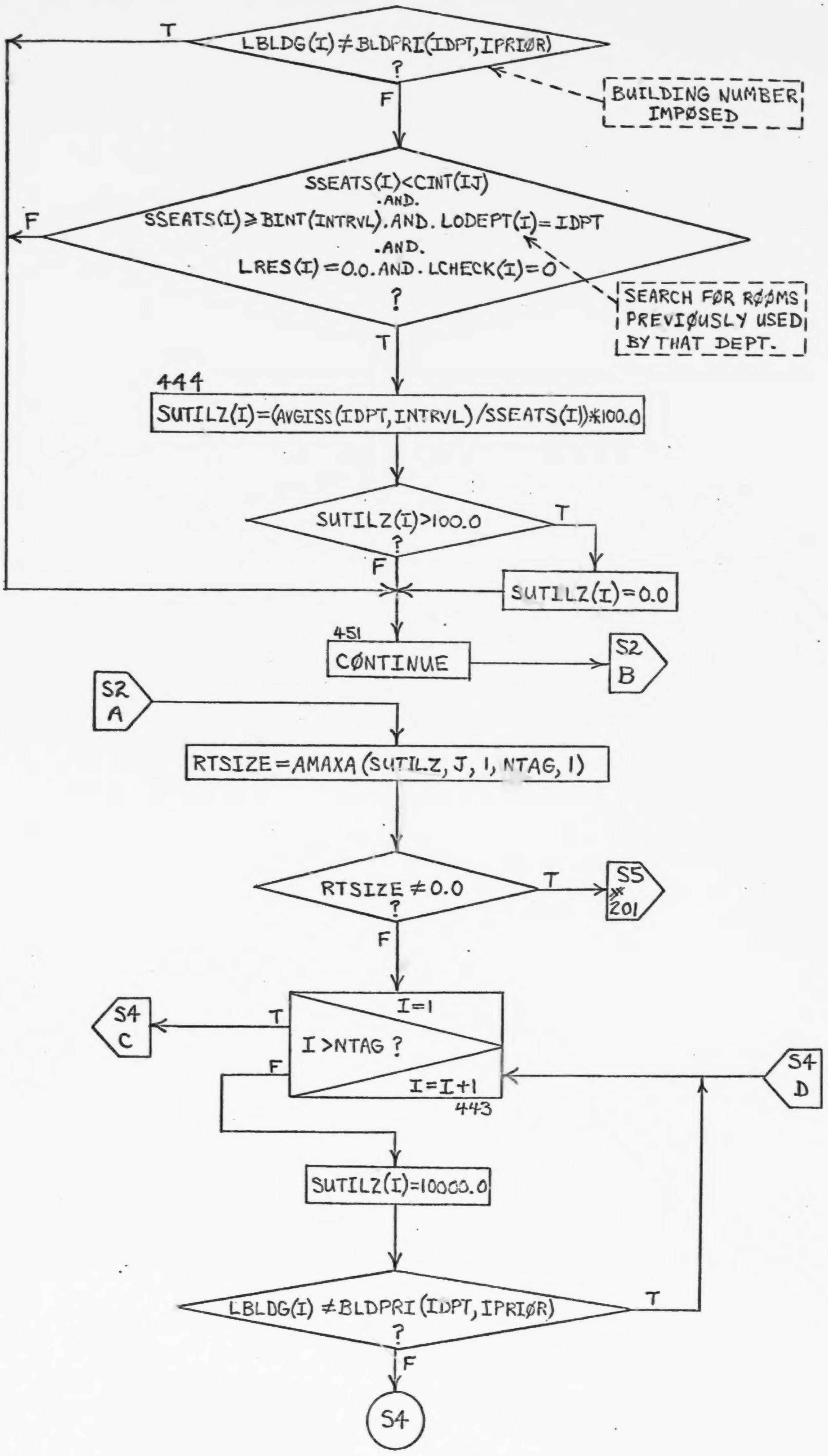

SUBROUTINE
ENTER
SEARCH
SEARCH FOR ROOMS TO SATISFY DEPARTMENTAL REQUIREMENTS
SEARCH FROM LIST OF DEPARTMENTAL BUILDING PRIORITIES
BUILDING NUMBER=ZERO ?
T
F
SEARCH FOR THE BEST SIZED ROOM FROM ALL THE ROOMS ON CAMPUS
SEARCH IN THE PARTICULAR BUILDING FOR A SUITABLE ROOM PREVIOUSLY ASSIGNED TO THE DEPARTMENT
NO
ROOM FOUND ?
YES
YES
ROOM FOUND ?
NO
TAG ROOM AS SUITABLE FOR THAT DEPARTMENT
SEARCH FOR ANY ROOM OF THE CORRECT SIZE IN THE BUILDING
STORE EXPECTED SEAT UTILIZATION
YES
ROOM FOUND ?
NO
RETURN

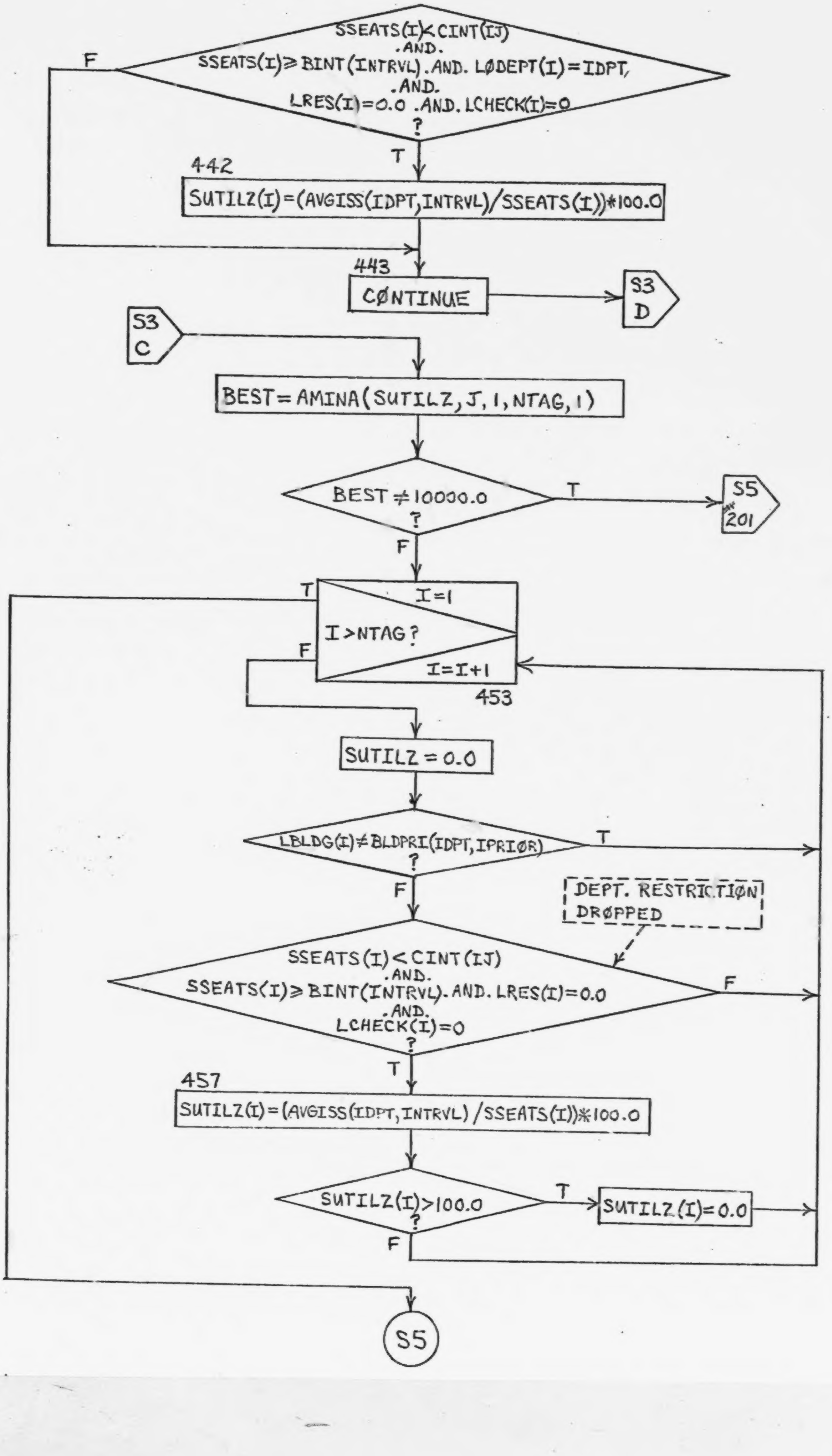

ENTER
DATA BLANK/4HZERO/
S5 #201
T
IPRIOR=1
IPRIOR>NPRIOR?
F
IPRIOR =IPRIOR+1
450
S5 A
BLDPRI(IDPT,IPRIOR)≠BLANK ?
T
S2 #452
F
IF BUILDING NO. = ZERO SEARCH FOR ANY AVAILABLE ROOM IN THE UNIVERSITY.
T
I=1
I >NTAG ?
F
I=I+1
449
SUTILZ(I)= 0.0
NO BUILDING RESTRICTION
SSEATS(I) < CINT(IJ) .AND. SSEATS(I) ≥ BINT(INTRVL) .AND. LRES(I) = 0.0 .AND. LCHECK(I) = 0 ?
F
T
448
SUTILZ(I)=(AVGISS(IDPT,INTRVL)/SSEATS(I))*100.0
SEARCH FOR ROOMS WITH SUTILZ ≤ 100.0
SUTILZ(I)>100.0?
T
F
SUTILZ(I)= 0.0
449
CONTINUE
RTSIZE= AMAXA (SUTILZ, J, 1, NTAG, 1)
PICK SEAT UTILIZATION CLOSEST TO 100%
S2

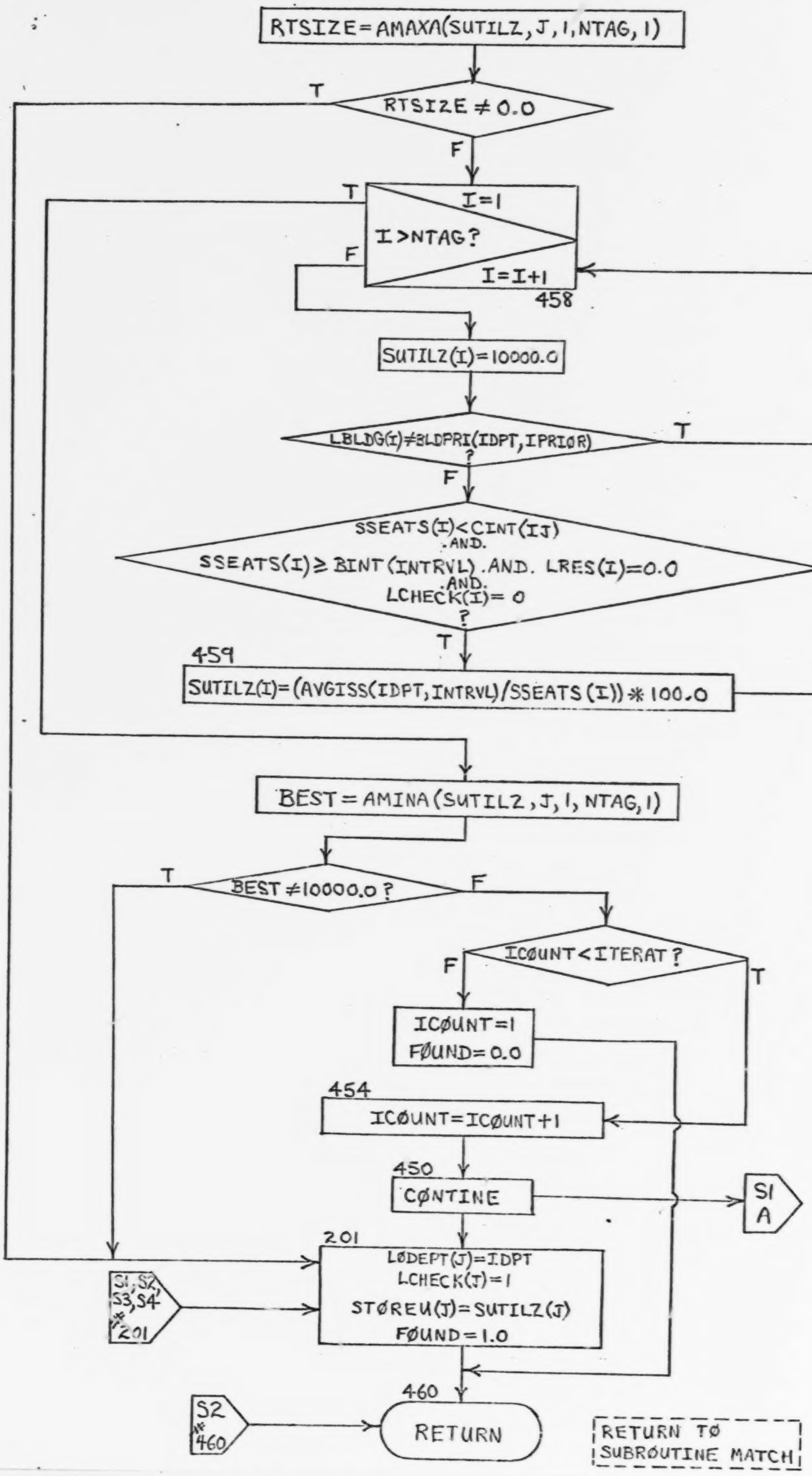
S2


RTSIZE ≠ 0.0 ?
T
S5
# 201
F
I=1
I > NTAG?
I=I+1
T
F
446
SUTILZ(I)=10000.0
SSEATS(I)<CINT(IJ)
.AND.
SSEATS(I) > BINT(INTRVL). AND. LRES(I) = 0.0
.AND.
LCHECK(I)=0
?
F
T
445
SUTILZ(I)=(AVGISS(IDPT,INTRVL)/SSEATS(I))*100.0
446
CONTINUE
BEST = AMINA(SUTILZ,J,1,NTAG,1)
PICK SUTILZ CLOSEST TO 100% BUT >100%
BEST ≠10000.0 ?
T
S5
# 201
F
FOUND=0.0
S5
# 460
S1
# 452
452
I=1
I >NTAG?
I=I+1
T
S3
A
F
451
S3
B
SUTILZ(I)=0.0
S3

4


LBLDG(I) ≠ BLDPRI(IDPT, IPRIØR) ?
T
F
BUILDING NUMBER IMPØSED
SSEATS(I)<CINT(IJ) .AND. SSEATS(I) ≥ BINT(INTRVL). AND. LODEPT(I) = IDPT .AND. LRES(I) = 0.0. AND. LCHECK(I) = 0 ?
F
T
SEARCH FØR RØØMS PREVIØUSLY USED BY THAT DEPT.
444
SUTILZ(I)=(AVGISS(IDPT, INTRVL)/SSEATS(I))*100.0
SUTILZ(I)>100.0 ?
T
F
SUTILZ(I)=0.0
451
CØNTINUE
S2 B
S2 A
RTSIZE=AMAXA(SUTILZ, J, 1, NTAG, 1)
RTSIZE ≠ 0.0 ?
T
F
S5 * 201
I=1
I >NTAG ?
I=I+1
443
T
F
S4 C
S4 D
SUTILZ(I)=10000.0
LBLDG(I) ≠ BLDPRI(IDPT, IPRIØR) ?
T
F
S4


SSEATS(I)<CINT(IJ) .AND. SSEATS(I)≥BINT(INTRVL).AND. LØDEPT(I)=IDPT, .AND. LRES(I)=0.0 .AND. LCHECK(I)=0 ?
F
T
442
SUTILZ(I)=(AVGISS(IDPT,INTRVL)/SSEATS(I))*100.0
443
CØNTINUE
S3 D
S3 C
BEST=AMINA(SUTILZ,J,1,NTAG,1)
BEST≠10000.0 ?
T
S5 #201
F
T
I=1
I>NTAG?
F
I=I+1
453
SUTILZ=0.0
LBLDG(I)≠BLDPRI(IDPT,IPRIØR) ?
T
F
DEPT. RESTRICTIØN DRØPPED
SSEATS(I)<CINT(IJ) .AND. SSEATS(I)≥BINT(INTRVL).AND. LRES(I)=0.0 .AND. LCHECK(I)=0 ?
F
T
457
SUTILZ(I)=(AVGISS(IDPT,INTRVL)/SSEATS(I))*100.0
SUTILZ(I)>100.0 ?
T
SUTILZ(I)=0.0
F
S5


RTSIZE=AMAXA(SUTILZ, J, 1, NTAG, 1)
RTSIZE ≠ 0.0
T
F
I=1
I >NTAG?
I=I+1
T
F
458
SUTILZ(I)=10000.0
LBLDG(I)≠BLDPRI(IDPT, IPRIØR)?
T
F
SSEATS(I)<CINT(IJ) .AND. SSEATS(I) ≥ BINT(INTRVL) .AND. LRES(I)=0.0 .AND. LCHECK(I)= 0 ?
F
T
459
SUTILZ(I)=(AVGISS(IDPT, INTRVL)/SSEATS(I)) * 100.0
BEST=AMINA(SUTILZ, J, 1, NTAG, 1)
BEST ≠10000.0 ?
T
F
ICØUNT<ITERAT ?
F
T
ICØUNT=1
FØUND=0.0
454
ICØUNT=ICØUNT+1
450
CØNTINE
S1
A
201
LØDEPT(J)=IDPT
LCHECK(J)=1
STØREU(J)=SUTILZ(J)
FØUND=1.0
S1, S2, S3, S4 # 201
460
S2 # 460
RETURN
RETURN TØ SUBRØUTINE MATCH

```
C***********************************************************************
C     SUBROUTINE SEARCH.  THIS SUBROUTINE ENDEAVOURS TO SATISFY A DEPARTMENT,S
C     ROOM REQUIREMENTS BY SELECTING A ROOM AS CLOSE AS POSSIBLE TO THE HOME
C     OFFICES OF THE DEPARTMENT AND A ROOM WITH THE BEST SEAT UTILIZATION.
C     THE PROGRAM SEARCHES THROUGH A DEPARTMENT,S LIST OF BUILDINGS FOR A ROOM
C     CLOSE TO A DEPARTMENT,S AVERAGE INTERVAL SECTION SIZE(AVGISS). THE
C     EXPECTED SEAT UTILIZATION IS CALCULATED BY DIVIDING AVGISS BY THE NUMBER
C     OF SEATS IN THE ROOM. THE ROOM HAVING A SEAT UTILIZATION CLOSEST TO 100
C     PERCENT IS ASSIGNED.
C***********************************************************************
      SUBROUTINE SEARCH(INTRVL,IJ,IDPT,ICOUNT,FOUND,ITERAT)
      COMMON BLDG(250,3),NBLDG(250),NROOM(250),CCOST(7),   SEATS(250),
     *NODEPT(250),NRES(250),NUPDTE(250),SQFT(250),SQPERS(250),
     *DEVIAT(250),BBLDG(250,3),LBLDG(250),LROOM(250),ROMEAN(7),
     *SSEATS(250),LODEPT(250),LRES(250),LUPDTE(250),SSQFT(250),
     *NCHECK(250),LCHECK(250),RMTOT(7),SEATOT(7),RMHRTO(7),RMHRS(100,7),
     *ITEST(100,9),ROLEES(100,9),STR(100,9),HL(100,9),ROMHRS(100,9),
     *FACHRS(20,7),AMTOFF(100),ROLEED(250,7),DIST(250,7),BINT(8),
     *FACRMS(20,7),AMIDPT(7),URMS(7),DPNAME(100,4),TRMHRS(7),NDIST,NDP,
     *IACA,NINT1,UTEAWK,SUTIL,RUTIL,NTOTAL,NTAG,INIT1,STORED(250),
     *DRUTIL(100),TEAWK(100),ASSIGN(100)  ,BLDPRI(100,5),AVGISS(100,7),
     *REMRMS(100,7),RROOMS(100,7),SUTILZ(250),           NPRIOR,
     *RMSASN(7),DIFFHR(7),DIFFRM(7),HRUTIL(7),HRDEV(7),HRLACK(7)
     *,CINT(8),SQFTOT(7),RMTOTC(7),AVGINT(7), SIMYR,CPRMS(7),CPSEAT(7),
     *CPRMHR(7),UNSATI(7),CPDEV(7),SUSIZE(7),NDPFAC(20),NFAC(250),
     *LFAC(250),FACNAM(20,4),MATCHE(7),NOTMAT(7),PERMAT(7),NFACUL,
     *EFFMAT,EFFSAT,SUMMAX(20),PERSAT(7),RMDIFF(10,7),SKIP,SSTOP,IEND,
     *IBEGIN,COSTIN;COSTOT,ISIMYR,ROUND,MROUND,SULOW,BLDPER,CSQFT(7),
     *NINT2,OVERSU,DINT(8),RMTOTD(7),SULOWD,THIS
      REAL NRES,LRES,NBLDG,LBLDG,NROOM,LROOM
      DATA BLANK/4HZERO/
C***********************************************************************
C     IF A BUILDING NUMBER OF ZERO IS SPECIFIED FOR A GIVEN DEPARTMENT, THE
C     FOLLOWING STATEMENTS SEARCH FOR A ROOM ANYWHERE IN THE UNIVERSITY RATHER
C     THAN IN A SPECIFIC BUILDING. THE SEAT UTILIZATION FOR ALL ROOMS IN A GIVEN
C     SIZE INTERVAL IS CALCULATED AND THE VALUE CLOSEST TO BUT NOT GREATER THAN
C     100 PERCENT IS SELECTED. IF NO SUITABLE ROOM IS FOUND, A ROOM WITH A SEAT
C     UTILIZATION CLOSEST TO BUT GREATER THAN 100 PERCENT IS SELECTED.
C     RTSIZE REPRESENTS THE SEAT UTILIZATION CLOSEST TO 100 PERCENT FROM THE
C     ARRAY SUTILZ CONTAINING SEAT UTILIZATIONS NOT GREATER THAN 100 PERCENT.
C     BEST REPRESENT THE SEAT UTILIZATION CLOSEST TO 100 PERCENT FROM THE ARRAY
C     SUTILZ WHEN THE ARRAY CONTAINS ONLY SEAT UTILIZATIONS OF GREATER THAN
C     100 PERCENT.
C***********************************************************************
      DO 450 IPRIOR=1,NPRIOR
      IF(BLDPRI(IDPT,IPRIOR).NE.BLANK) GO TO 452
      DO 449 I=1,NTAG
      SUTILZ(I)=0.0
      IF(SSEATS(I).LT.CINT(IJ).AND.SSEATS(I).GE.BINT(INTRVL).AND.
     *LRES(I).EQ.0.0.AND.LCHECK(I).EQ.0)GO TO 448
      GO TO 449
  448 SUTILZ(I)=(AVGISS(IDPT,INTRVL)/SSEATS(I))*100.0
      IF(SUTILZ(I).GT.100.0) SUTILZ(I)=0.0
  449 CONTINUE
      RTSIZE=AMAXA(SUTILZ,J,1,NTAG,1)
      IF(RTSIZE.NE.0.0) GO TO 201
      DO 446 I=1,NTAG
      SUTILZ(I)=10000.0
      IF(SSEATS(I).LT.CINT(IJ).AND.SSEATS(I).GE.BINT(INTRVL).AND.
     *LRES(I).EQ.0.0.AND.LCHECK(I).EQ.0) GO TO 445
      GO TO 446
  445 SUTILZ(I)=(AVGISS(IDPT,INTRVL)/SSEATS(I))*100.0
  446 CONTINUE
      BEST=AMINA(SUTILZ,J,1,NTAG,1)
      IF(BEST.NE.10000.0) GO TO 201
      FOUND=0.0
      GO TO 460
C***********************************************************************
C     IF A BUILDING NUMBER OTHER THAN ZERO IS SPECIFIED, THE PROGRAM FIRST
C     SEARCHES FOR AN APPROPRIATE ROOM PREVIOUSLY ASSIGNED TO THAT DEPARTMENT
C     IN THE SPECIFIED BUILDING.
C***********************************************************************
  452 DO 451 I=1,NTAG
      SUTILZ(I)=0.0
      IF(LBLDG(I).NE.BLDPRI(IDPT,IPRIOR)) GO TO 451
      IF(SSEATS(I).LT.CINT(IJ).AND.SSEATS(I).GE.BINT(INTRVL).AND.
     *LODEPT(I).EQ.IDPT.AND.LRES(I).EQ.0.0.AND.LCHECK(I).EQ.0)GO TO 444
      GO TO 451
  444 SUTILZ(I)=(AVGISS(IDPT,INTRVL)/SSEATS(I))*100.0
      IF(SUTILZ(I).GT.100.0)SUTILZ(I)=0.0
  451 CONTINUE
      RTSIZE=AMAXA(SUTILZ,J,1,NTAG,1)
      IF(RTSIZE.NE.0.0)GO TO 201
      DO 443 I=1,NTAG
      SUTILZ(I)=10000.0
      IF(LBLDG(I).NE.BLDPRI(IDPT,IPRIOR)) GO TO 443
      IF(SSEATS(I).LT.CINT(IJ).AND.SSEATS(I).GE.BINT(INTRVL).AND.
     *LODEPT(I).EQ.IDPT.AND.LRES(I).EQ.0.0.AND.LCHECK(I).EQ.0)GO TO 442
      GO TO 443
  442 SUTILZ(I)=(AVGISS(IDPT,INTRVL)/SSEATS(I))*100.0
  443 CONTINUE
      BEST=AMINA(SUTILZ,J,1,NTAG,1)
      IF(BEST.NE.10000.0) GO TO 201
C***********************************************************************
C     IF NO SUITABLE ROOM PREVIOUSLY ASSIGNED TO A DEPARTMENT EXISTS, SEARCH
C     FOR ANY OTHER APPROPRIATE ROOMS IN THE BUILDING.
C***********************************************************************
      DO 453 I=1,NTAG
      SUTILZ(I)=0.0
      IF(LBLDG(I).NE.BLDPRI(IDPT,IPRIOR)) GO TO 453
      IF(SSEATS(I).LT.CINT(IJ).AND.SSEATS(I).GE.BINT(INTRVL).AND.
     *LRES(I).EQ.0.0.AND.LCHECK(I).EQ.0)GO TO 457
      GO TO 453
  457 SUTILZ(I)=(AVGISS(IDPT,INTRVL)/SSEATS(I))*100.0
      IF(SUTILZ(I).GT.100.0) SUTILZ(I)=0.0
  453 CONTINUE
      RTSIZE=AMAXA(SUTILZ,J,1,NTAG,1)
      IF(RTSIZE.NE.0.0)GO TO 201
      DO 458 I=1,NTAG
      SUTILZ(I)=10000.0
      IF(LBLDG(I).NE.BLDPRI(IDPT,IPRIOR)) GO TO 458
      IF(SSEATS(I).LT.CINT(IJ).AND.SSEATS(I).GE.BINT(INTRVL).AND.
     *LRES(I).EQ.0.0.AND.LCHECK(I).EQ.0) GO TO 459
      GO TO 458
  459 SUTILZ(I)=(AVGISS(IDPT,INTRVL)/SSEATS(I))*100.0
  458 CONTINUE
      BEST=AMINA(SUTILZ,J,1,NTAG,1)
      IF(BEST.NE.10000.0) GO TO 201
C***********************************************************************
C     ONLY ONE ROOM AT A TIME IS ASSIGNED TO ANY DEPARTMENT. THE DEPARTMENTAL
```

```
C     REQUIREMENTS ARE MATCHED IN ORDER FROM ONE TO NDP. BUILDINGS OF LOWER
C     PRIORITY ON A DEPARTMENT,S LIST ARE EXAMINED ONLY AFTER THE BUILDING OF
C     FIRST PRIORITY HAS BEEN SEARCHED. SECOND, THIRD, FOURTH, ETC., PRIORITY
C     BUILDINGS CAN ONLY BE REACHED ON THE SECOND, THIRD, FOURTH, ETC.,
C     ITERATION RESPECTIVELY.  PROGRAM CONTROL COMPARES A COUNTER ICOUNT
C     REPRESENTING THE NUMBER OF BUILDINGS SEARCHED TO ITERAT--THE NUMBER OF
C     ITERATIONS OF SEARCHING THAT HAVE BEEN DONE FOR ALL DEPARTMENTS.
C*******************************************************************************
      IF(ICOUNT.LT.ITERAT) GO TO 454
      ICOUNT=1
      FOUND=0.0
      GO TO 460
  454 ICOUNT=ICOUNT+1
  450 CONTINUE
C*******************************************************************************
C     TAG THE ROOM DEPARTMENTAL AFFILIATION NUMBER WITH THE CURRENT DEPARTMENT
C     NUMBER AND SET THE ROOM,S CHECK BIT TO ONE. STORE THE EXPECTED SEAT
C     UTILIZATION AND INDICATE A ROOM HAS BEEN FOUND(FOUND=1.0)
C*******************************************************************************
  201 LODEPT(J)=IDPT
      LCHECK(J)=1
      STOREU(J)=SUTILZ(J)
      FOUND=1.0
  460 RETURN
      END

   145*CARDS
```

APPENDIX C

Contents: Description of input data and input data listing

```
$DATA

                PAGE    1                      OCT  6 1967

NDP,NFACUL,NDIST,NTOTAL,NPRIOR,IACA,NINT1,IBEGIN,IEND--INTEGER PARAMETERS
 47  3181227  4  9  5 66 66

UTEAWK,SUTAL,RUTIL,SSTOP,SKIP,SULOW,SULOWD,THIS,COSTIN--REAL PARAMETERS
 35.0100.0 60.0  1.0  0.0 60.0100.0  5.0 20.0

PRESENT AND PROPOSED LECTURE ROOM FACILITIES-
BUILDING NAME, BUILDING NO., ROOM NO., NO. OF SEATS, DEPT.NO., RESTRICTED HOURS
UPDATING CODE, SQUARE FOOTAGE, CHECK BIT, FACULTY NO.

ANATOMY BUILDING      4   211   100      0001020.0
ANATOMY BUILDING      4   111   230      0002570.0
ARCHITECTURE BLDG    28   107    56      000 836.0
ARCHITECTURE BLDG    28   104    56      000 709.0
ARCHITECTURE BLDG    28   105    60      000 714.0
ARCHITECTURE BLDG    28   103   170      0001597.0
BANTING INSTITUTE    16   131   190      0002520.0
BEST INSTITUTE       52   114   215      0001950.0
BOTANY BUILDING      11   203    35      000 522.0
BOTANY BUILDING      11     6   179      0001832.0
SCHOOL OF BUSINESS   38   209    14      000 455.0
SCHOOL OF BUSINESS   38   311    20      000 450.0
SCHOOL OF BUSINESS   38   203    85      0001021.0
CONSERV. OF MUSIC   100   309A    8      000 182.0
CONSERV. OF MUSIC   100   329    20      000 146.0
EDWARD JOHNSON       51   215    20      000 493.0
EDWARD JOHNSON       51   108    40      000 548.0
EDWARD JOHNSON       51   109    40      000 566.0
EDWARD JOHNSON       51   120    40      000 499.0
EDWARD JOHNSON       51   209    40      000 526.0
EDWARD JOHNSON       51   216    40      000 644.0
EDWARD JOHNSON       51   217    40      000 534.0
EDWARD JOHNSON       51   224    40      000 473.0
EDWARD JOHNSON       51   225    40      000 516.0
EDWARD JOHNSON       51    78    75      0002190.0
EDWARD JOHNSON       51   119    75      0002255.0
EDWARD JOHNSON       51   116   108      0001235.0
ELECTRICAL BLDG      20    21   125      3671250.0
ELECTRICAL BLDG      20    23   125      3671250.0
ELECTRICAL BLDG      20    34   125      3671250.0
EXTENSION DIVISION   50   108    80      000 882.0
FOOD SCIENCES        15   312    48      000 617.0
FOOD SCIENCES        15   314    53      000 676.0
FOOD SCIENCES        15   216    60      000 685.0
FOOD SCIENCES        15   218    74      000 786.0
FOOD SCIENCES        15    24    90      0002134.0
FOOD SCIENCES        15   117   125      0001319.0
FORESTRY BUILDING    27   209    35      000 412.0
FORESTRY BUILDING    27   110    40      000 420.0
FORESTRY BUILDING    27   301    73      000 802.0
GALBRAITH BUILDING   70   116    30      000 539.0
GALBRAITH BUILDING   70   216    30      000 644.0
GALBRAITH BUILDING   70   314    30      000 649.0
GALBRAITH BUILDING   70   415    30      000 649.0
GALBRAITH BUILDING   70   119   102      000 956.0
GALBRAITH BUILDING   70   120   102      000 955.0
GALBRAITH BUILDING 70    220    102     000 956.0
GALBRAITH BUILDING 70    221    102     000 955.0
GALBRAITH BUILDING 70    244    102     0001059.0
GALBRAITH BUILDING 70    248    102     0001059.0
HYGIENE BUILDING   25    127     18     000 214.0
HYGIENE BUILDING   25    128     25     000 302.0
HYGIENE BUILDING   25    423     35     000 740.0
HYGIENE BUILDING   25    129     50     000 546.0
HYGIENE BUILDING   25    236     50     0001019.0
HYGIENE BUILDING   25    103    150     0001896.0
LASH MILLER BLDG   73    123     40     000 535.0
LASH MILLER BLDG   73    157     42     000 479.0
LASH MILLER BLDG   73    155     50     000 407.0
LASH MILLER BLDG   73    158     98     0001350.0
LASH MILLER BLDG   73    161    128     0001905.0
LASH MILLER BLDG   73    162    154     0001141.0
LASH MILLER BLDG   73    159    208     0002445.0
LIBRARY SCIENCE B  83A   201     10     000 245.0
LIBRARY SCIENCE B  83A   202     40     000 693.0
LIBRARY SCIENCE B  83A   208     40     000 693.0
LIBRARY SCIENCE A  83B      A    40     000 650.0
LIBRARY SCIENCE A  83B      C    40     000 650.0
LIBRARY SCIENCE A  83B      D    40     000 630.0
LIBRARY SCIENCE A  83B      B    80     0001810.0
MECHANICAL BLDG    20    336     12     000 323.0
MECHANICAL BLDG    20    252    128     0001410.0
MECHANICAL BLDG    20    254    128     0001270.0
MECHANICAL BLDG    20    102    350     0003760.0
MEDICAL BUILDING    4    215     25     000 454.0
MEDICAL BUILDING    4    128    328     0002606.0
MILL BUILDING       7    302     10     000 773.0
MILL BUILDING       7    316     24     000 943.0
MILL BUILDING       7    311     30     000 728.0
MINING BUILDING     7    302     25     000 400.0
MINING BUILDING     7    202     60     000 600.0
MINING BUILDING     7    206     77     000 875.0
MINING BUILDING     7    130     79     000 770.0
MINING BUILDING     7    101     80     000 835.0
MINING BUILDING     7    128    202     0002500.0
NEW COLLEGE        32     68     16     000 230.0
NEW COLLEGE        32     77     16     000 227.0
NEW COLLEGE        32     76     20     000 278.0
NEW COLLEGE        32     69     21     000 297.0
NEW COLLEGE        32     74     21     000 312.0
NEW COLLEGE        32     75     22     000 355.0
NEW PHYSICS BLDG   78A    53     25     000 306.0
NEW PHYSICS BLDG   78A   713     25     000 296.0
NEW PHYSICS BLDG   78A   118     40     000 465.0
NEW PHYSICS BLDG   78A   257     40     000 520.0
NEW PHYSICS BLDG   78A   373     40     000 487.0
NEW PHYSICS BLDG   78A   134A    93     0001144.0
NEW PHYSICS BLDG   78A   137A    93     0001143.0
NEW PHYSICS BLDG   78A   102    196     0002356.0
NEW PHYSICS BLDG   78A   103    196     0002496.0
NEW PHYSICS BLDG   78A   202    196     0002495.0
NEW PHYSICS BLDG   78A   203    196     0002495.0
SCHOOL OF NURSING  36    115     15     000 391.0
SCHOOL OF NURSING  36     52     24     000 425.0
SCHOOL OF NURSING  36    104     50     000 562.0
SCHOOL OF NURSING  36   101   70   000 755.0
SCHOOL OF NURSING  36   102  120   0001200.0
SCHOOL OF NURSING  36   107  350   0002560.0
OLD PHSICS BLDG     9   211   40   000 710.0
OLD PHSICS BLDG     9   101  100   000 728.0
OLD PHSICS BLDG     9   132  200   0001522.0
OLD PHSICS BLDG     9   135  560   0003705.0
PHARMACY BUILDING  79   310   46   000 708.0
PHARMACY BUILDING  79   411   78   000 671.0
PHARMACY BUILDING  79   105  144   0001519.0
RAMSAY WRIGHT BLDG 72   141   20   000 358.0
RAMSAY WRIGHT BLDG 72   142   40   000 627.0
RAMSAY WRIGHT BLDG 72   432   46   0001138.0
RAMSAY WRIGHT BLDG 72   143   60   000 752.0
RAMSAY WRIGHT BLDG 72   229   60   0001000.0
RAMSAY WRIGHT BLDG 72   110  150   0002020.0
RAMSAY WRIGHT BLDG 72   117  150   0002020.0
ROYAL ONT  MUSEUM  17    64  120   0001200.0
ROYAL ONT  MUSEUM  17    61  459   0005000.0
SIDNEY SMITH HALL  33   504   20   000 337.0
SIDNEY SMITH HALL  33   539   20   000 319.0
SIDNEY SMITH HALL  33   590   20   000 249.0
SIDNEY SMITH HALL  33  1028   15   000 167.0
SIDNEY SMITH HALL  33  1032   14   000 167.0
SIDNEY SMITH HALL  33  1067   10   000 144.0
SIDNEY SMITH HALL  33  1091   15   000 144.0
SIDNEY SMITH HALL  33  2042   14   000 197.0
SIDNEY SMITH HALL  33  2046   14   000 197.0
SIDNEY SMITH HALL  33  2050   20   000 197.0
SIDNEY SMITH HALL  33  2100   10   000 141.0
SIDNEY SMITH HALL  33  2101   15   000 210.0
SIDNEY SMITH HALL  33  2112   10   000 211.0
SIDNEY SMITH HALL  33  2114   10   000 198.0
SIDNEY SMITH HALL  33  2115   15   000 198.0
SIDNEY SMITH HALL  33  2116   15   000 198.0
SIDNEY SMITH HALL  33  2119   15   000 198.0
SIDNEY SMITH HALL  33  2120   15   000 198.0
SIDNEY SMITH HALL  33  2121   15   000 202.0
SIDNEY SMITH HALL  33  2123   15   000 211.0
SIDNEY SMITH HALL  33  2131   20   000 211.0
SIDNEY SMITH HALL  33  2133   10   000 144.0
SIDNEY SMITH HALL  33  2134   10   000 210.0
SIDNEY SMITH HALL  33  3002   15   000 179.0
SIDNEY SMITH HALL  33  3041   15   000 198.0
SIDNEY SMITH HALL  33  3045   15   000 203.0
SIDNEY SMITH HALL  33  4034   15   000 203.0
SIDNEY SMITH HALL  33  4038   15   000 202.0
SIDNEY SMITH HALL  33  4047   15   000 202.0
SIDNEY SMITH HALL  33  5004   15   000 220.0
SIDNEY SMITH HALL  33  5020   15   000 203.0
SIDNEY SMITH HALL  33  6003   12   000 205.0
SIDNEY SMITH HALL  33  6054   12   000 205.0
SIDNEY SMITH HALL  33   592   74   000 660.0
SIDNEY SMITH HALL  33   597   74   000 762.0
SIDNEY SMITH HALL  33   612   77   000 722.0
SIDNEY SMITH HALL  33  1021   50   000 581.0
SIDNEY SMITH HALL  33  1022   50   000 570.0
SIDNEY SMITH HALL  33  1069   98   0001089.0
SIDNEY SMITH HALL  33  1070   68   000 748.0
SIDNEY SMITH HALL   33   1071     98      000 979.0
SIDNEY SMITH HALL   33   1072     68      000 748.0
SIDNEY SMITH HALL   33   1073     98      000 979.0
SIDNEY SMITH HALL   33   1074     68      000 767.0
SIDNEY SMITH HALL   33   1083     98      0001128.0
SIDNEY SMITH HALL   33   1084     69      000 740.0
SIDNEY SMITH HALL   33   1085     98      0001128.0
SIDNEY SMITH HALL   33   1086     69      000 740.0
SIDNEY SMITH HALL   33   1087     98      0001128.0
SIDNEY SMITH HALL   33   1088     69      000 740.0
SIDNEY SMITH HALL   33   2102    198      0001743.0
SIDNEY SMITH HALL   33   2106     80      0001087.0
SIDNEY SMITH HALL   33   2108     80      0001107.0
SIDNEY SMITH HALL   33   2110     80      0001107.0
SIDNEY SMITH HALL   33   2117    198      0001746.0
SIDNEY SMITH HALL   33   2118    198      0001746.0
SIDNEY SMITH HALL   33   2125     80      0001072.0
SIDNEY SMITH HALL   33   2127     80      0001072.0
SIDNEY SMITH HALL   33   2129     80      0001072.0
SIDNEY SMITH HALL   33   2135    198      0001743.0
SUSSEX COURT        77    125     20      000 228.0
SUSSEX COURT        77    103     25      000 283.0
SUSSEX COURT        77    117     25      000 306.0
UNIVERSITY COLLEGE   1     11     20      000 374.0
UNIVERSITY COLLEGE   1     12     50      000 596.0
UNIVERSITY COLLEGE   1     13     50      000 596.0
UNIVERSITY COLLEGE   1     14     25      000 374.0
UNIVERSITY COLLEGE   1   105D     12      000 276.0
UNIVERSITY COLLEGE   1   201F     30      000 176.0
UNIVERSITY COLLEGE   1   203B     20      000 320.0
UNIVERSITY COLLEGE   1   204A     23      000 342.0
UNIVERSITY COLLEGE   1    219     22      000 347.0
UNIVERSITY COLLEGE   1    221     30      000 357.0
UNIVERSITY COLLEGE   1    231     30      000 674.0
UNIVERSITY COLLEGE   1   301D     20      000 452.0
UNIVERSITY COLLEGE   1    313     21      000 416.0
UNIVERSITY COLLEGE   1    314     25      000 519.0
UNIVERSITY COLLEGE   1    315     21      000 364.0
UNIVERSITY COLLEGE   1    12H     70      000 700.0
UNIVERSITY COLLEGE   1   101A     68      000 773.0
UNIVERSITY COLLEGE   1    103     61      000 655.0
UNIVERSITY COLLEGE   1    104    120      0001225.0
UNIVERSITY COLLEGE   1    106    145      0001400.0
UNIVERSITY COLLEGE   1    108     48      000 555.0
UNIVERSITY COLLEGE   1    118     90      000 940.0
UNIVERSITY COLLEGE   1    122    103      000 985.0
UNIVERSITY COLLEGE   1    129     66      000 618.0
UNIVERSITY COLLEGE   1    133     40      000 384.0
UNIVERSITY COLLEGE   1    135     56      000 596.0
UNIVERSITY COLLEGE   1    138    140      0001245.0
UNIVERSITY COLLEGE   1    206     43      000 416.0
UNIVERSITY COLLEGE   1    214     98      000 982.0
UNIVERSITY COLLEGE   1    220     50      000 605.0
UNIVERSITY COLLEGE   1    224     44      000 387.0
UNIVERSITY COLLEGE   1    228     50      000 616.0
WALLBERG BUILDING    8   202A     15      000 522.0
WALLBERG BUILDING    8   2035     50      0001282.0
WALLBERG BUILDING    8   3037     50      0001402.0
WALLBERG BUILDING    8    116     69      000 755.0
WALLBERG BUILDING   8    123    160      0001524.0
WALLBERG BUILDING   8   1033    135      0001514.0
WALLBERG BUILDING   8   1035    230      0002420.0
WALLBERG BUILDING   8   2034    151      0001628.0

FORECASTED ENROLMENT, FORECASTED CLASS SIZES, HOURS/WEEK/SECTION, TEST BIT

 310.0155.02.001
 224.0112.03.001
 160.0 80.03.001
 296.0 98.72.331
 204.0 68.02.331
 107.0 17.82.831
 230.0 25.52.561
   0.0  0.00.000
  52.0  4.73.000
 115.0 57.52.001
 110.0 55.01.501
   0.0  0.00.000
   0.0  0.00.000
  36.0 36.01.000
  25.0 25.02.000
  20.0  6.71.700
   0.0  0.00.000
  23.0  3.81.700
 439.0 73.21.171
  83.0 27.71.331
 277.0 39.61.001
 344.0 86.01.251
 122.0 30.52.001
 106.0 15.11.571
  53.0  6.61.000
   0.0  0.00.000
  16.0  2.31.140
 462.0154.02.330
 306.0102.02.001
 123.0 62.02.001
 695.0 86.92.311
 835.0 64.21.921
 280.0 25.51.591
 161.0 26.92.001
   0.0  0.00.000
  92.0 11.52.001
  22.0  5.54.000
  40.0 13.33.671
  50.0 25.03.501
  23.0  5.84.750
  17.0  2.42.710
  26.0  4.32.830
  16.0  2.72.830
   0.0  0.00.000
   6.0  1.01.830
  68.0 68.03.000
 142.0 71.02.001
 154.0 77.02.001
 164.0 41.02.131
 114.0 28.51.381
  85.0 21.31.751
 103.0 25.82.001
   0.0  0.00.000
  32.0  6.42.000
 393.0131.02.001
 142.0 71.02.501
  94.0 47.02.001
 218.0109.01.501
 227.0 32.41.711
 118.0 29.52.000
 158.0 14.42.001
   0.0  0.00.000
  12.0  6.03.000
 204.0 51.01.631
   0.0  0.00.000
   0.0  0.00.000
 200.0100.01.501
  67.0 22.32.001
 169.0 16.91.901
 134.0 16.82.001
   0.0  0.00.000
  13.0  3.32.500
 336.0336.02.000
 448.0224.02.001
 572.0143.02.001
 485.0243.02.000
 595.0 85.02.001
 487.0122.02.001
 410.0 12.11.821
   0.0  0.00.000
 195.0  8.12.000
   7.0  3.53.000
   3.0  1.53.000
   0.0  0.00.000
  12.0  4.02.670
   6.0  3.03.000
  14.0  2.32.000
   8.0  1.12.000
   0.0  0.00.000
   9.0  1.32.140
 434.0 31.04.000
 233.0 33.33.141
 123.0 20.53.001
 541.0 24.64.001
 264.0 29.32.561
 176.0 14.71.251
 197.0 12.31.381
   0.0  0.00.000
  71.0  4.72.000
 755.0108.01.711
 491.0 47.02.001
 309.0 39.02.001
1688.0 65.02.151
1222.0 56.02.001
 712.0 37.01.951
 286.0 16.02.001
   0.0  0.00.000
 248.0  8.02.001
 265.0 88.33.000
 271.0 90.33.001
 210.0 52.52.501
 513.0 51.33.001
 686.0 52.82.081
 204.0 11.31.831
 532.0 44.31.671
   0.0  0.00.000
 285.0  8.92.061
 493.0164.32.001
 310.0103.32.001
  45.0 45.02.000
1131.0113.12.801
 473.0 67.62.001
 299.0 27.21.821
 411.0 17.91.871
   0.0  0.00.000
 182.0  6.52.001
 646.0162.03.001
 924.0154.02.671
 542.0 90.02.341
 948.0 86.02.631
1609.0 95.02.651
1356.0 80.02.531
 901.0 29.02.031
   0.0  0.00.000
 348.0  8.72.001
 847.0141.02.801
 752.0150.03.001
 680.0113.03.001
 406.0 81.02.601
 388.0 49.02.001
 135.0 27.02.001
 172.0 21.02.001
   0.0  0.00.000
 106.0  6.22.000
  34.0 34.02.000
  22.0  7.32.000
  32.0 10.72.700
 114.0 22.82.201
  76.0 12.72.701
  70.0  7.01.601
  95.0 13.61.711
   0.0  0.00.000
  83.0  9.22.001
 834.0209.02.501
 696.0232.04.001
 304.0101.03.001
 229.0229.08.000
 150.0 50.03.001
 110.0 22.03.001
 139.0 18.02.121
   0.0  0.00.000
  84.0  5.61.800
 767.0109.61.901
 341.0 68.22.001
 435.0 54.41.881
 552.0 61.32.001
 323.0 46.12.141
 174.0 19.31.661
 193.0 13.81.321
   0.0  0.00.000
  14.0  7.02.000
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   88.0 29.33.331
  137.0 39.32.381
  125.0 25.02.401
  257.0 12.91.881
  126.0 21.01.751
   35.0 11.71.171
   79.0 11.31.211
    0.0  0.00.000
   31.0  3.42.000
  832.0 30.82.521
  577.0 41.22.790
  420.0 28.02.671
 1405.0 36.02.051
  408.0 34.01.971
  275.0 34.42.061
  636.0 35.31.361
    0.0  0.00.000
  212.0 11.22.000
  268.0134.02.001
  205.0 51.33.001
  118.0 39.32.331
    0.0  0.00.000
   14.0 14.02.000
   19.0  9.52.000
   24.0  8.01.330
    0.0  0.00.000
    0.0  0.00.000
  307.0  9.52.690
  279.0 23.02.100
  178.0 14.81.831
  496.0 15.51.631
  175.0 10.91.500
  230.0 15.32.671
  163.0 18.11.331
    0.0  0.00.000
   96.0  7.42.001
   20.0 20.03.000
  104.0 34.72.671
   57.0 11.42.401
  161.0 16.11.600
   50.0 10.02.000
   52.0 13.01.750
   36.0 12.02.000
    0.0  0.00.000
   56.0 14.03.001
  136.0 34.02.751
   73.0 24.02.331
   75.0 25.02.331
   25.0 12.52.500
    9.0  9.03.000
   10.0  2.53.000
   52.0 13.02.501
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
  406.0 51.02.000
  632.0 63.21.400
  546.0 42.01.980
  269.0 19.21.960
    0.0  0.00.000
   61.0  6.12.001
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
 1186.0 47.01.601
  545.0 55.01.651
  348.0 27.01.461
  378.0 18.91.551
    0.0  0.00.000
  123.0  6.52.030
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
  479.0 47.92.000
  614.0 72.21.881
  625.0 56.81.861
  626.0 29.81.361
    0.0  0.00.000
  159.0  9.41.881
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
   54.0 27.01.501
  216.0 43.21.600
    0.0  0.00.000
   57.0  8.12.430
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
  607.0 60.71.201
  834.0 49.11.321
  696.0 30.01.171
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
  196.0 65.31.501
  167.0 20.91.191
   71.0 14.21.600
    0.0  0.00.000
   60.0 20.01.171
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
   68.0 22.71.831
   50.0 10.01.400
    0.0  0.00.000
   69.0  4.91.430
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
  258.0 65.01.370
  247.0 49.01.300
  188.0 47.01.370
  144.0 36.0 .750
  176.0 44.0 .880
  241.0 21.91.821
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
   81.0 81.02.000
   45.0 45.02.000
  201.0 50.32.001
    0.0  0.00.000
  997.0 22.21.441
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
   24.0 12.02.000
    0.0  0.00.000
  186.0 11.62.380
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
  182.0 22.81.561
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
  500.0100.01.201
  375.0125.01.670
 1254.0105.01.251
  847.0121.01.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
  450.0 50.01.110
  396.0 44.01.220
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
   16.0 16.01.000
   59.0 19.71.331
   84.0 28.01.330
   35.0 11.71.330
   40.0  8.01.200
  141.0 20.11.291
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
    0.0  0.00.000
  55.0 13.81.750
 183.0 22.91.691
  45.0 11.31.131
   0.0  0.00.000
  13.0  1.61.250
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
1200.0 80.02.201
1080.0 64.01.501
 949.0 53.01.971
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
2199.0 38.60.941
 412.0206.02.001
 409.0204.52.001
 178.0 89.02.001
 425.0 21.31.551
 440.0 14.71.731
 315.0 10.81.621
 196.0 24.52.131
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
 674.0 35.53.321
  46.0 46.04.000
 196.0 39.21.800
  68.0 34.02.250
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
 145.0145.02.000
 422.0 84.01.401
 500.0 71.01.861
 638.0 53.01.541
   0.0  0.00.000
  22.0  3.11.280
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
 218.0 31.10.791
 274.0 34.31.000
 209.0 26.11.001
 154.0 15.41.501
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
   0.0  0.00.000
```

```
2084.0 24.01.501

SIZE INTERVAL MIDPOINTS

10.0 40.0 80.0 140.0250.0

SIZE INTERVAL END POINTS

  0.0 20.1 60.1100.1180.1999.0

DEPARTMENTAL ENROLMENT SIZE RANGE DISTRIBUTIONS

  0.0  0.0  0.0 40.6 59.4
  0.0  9.8  0.0  0.0 90.2
  0.0 15.2  0.0 84.8  0.0
  0.0 50.3  0.0 49.7  0.0
  0.0 39.7  0.0 60.3  0.0
 44.9 55.1  0.0  0.0  0.0
 29.6 15.7  0.0 54.7  0.0
  0.0 47.8 52.2  0.0  0.0
  0.0 25.5 74.5  0.0  0.0
  0.0  8.0 92.0  0.0  0.0
  7.2 92.8  0.0  0.0  0.0
  5.7 25.3 69.0  0.0  0.0
  0.0  0.0 60.8 39.2  0.0
  8.2 91.8  0.0  0.0  0.0
 50.9 49.1  0.0  0.0  0.0
  0.0 16.7  0.0 83.3  0.0
  0.0 48.0 52.0  0.0  0.0
  0.0  4.2 57.6 38.2  0.0
  0.5 26.5 31.6 41.4  0.0
 16.4 83.6  0.0  0.0  0.0
  8.1 61.9  0.0  0.0  0.0
 78.3 21.7  0.0  0.0  0.0
  7.5 92.5  0.0  0.0  0.0
  2.0 98.0  0.0  0.0  0.0
  0.0 35.2 64.8  0.0  0.0
  0.0 34.4  0.0 65.6  0.0
  2.4 56.7 40.9  0.0  0.0
  6.1 93.9  0.0  0.0  0.0
 34.1 65.9  0.0  0.0  0.0
 35.9 64.1  0.0  0.0  0.0
  1.3  0.0  0.0  0.0 98.7
  0.0 31.0 69.0  0.0  0.0
 17.0  0.0 83.0  0.0  0.0
  0.0  0.0 29.4 70.6  0.0
 15.9 57.3 26.9  0.0  0.0
 66.5 33.5  0.0  0.0  0.0
  0.0 53.4 46.6  0.0  0.0
  0.0 24.0  0.0 76.0  0.0
 26.9 73.1  0.0  0.0  0.0
 60.9 39.1  0.0  0.0  0.0
 27.6 72.4  0.0  0.0  0.0
  0.0  0.0 18.1  0.0 81.9
  0.0  0.0 41.8  0.0 58.2
  6.1  0.0 12.6 50.9 30.4
  3.7  0.0  0.0 96.3  0.0
 66.3 33.7  0.0  0.0  0.0
 10.7 25.3 63.9  0.0  0.0
 24.4 75.6  0.0  0.0  0.0
 21.4 78.6  0.0  0.0  0.0
 40.9 10.6 48.5  0.0  0.0
 84.1 15.9  0.0  0.0  0.0
 70.1 29.9  0.0  0.0  0.0
  0.0 12.0 20.8 38.3 28.9
  0.0 84.5 15.5  0.0  0.0
   .4 70.2 29.4  0.0  0.0
  0.0 22.9 57.2  7.5 12.3
  1.3 38.1 60.6  0.0  0.0
  6.9 75.8 17.3  0.0  0.0
 41.3 58.7  0.0  0.0  0.0
 48.8 51.2  0.0  0.0  0.0
  4.8  0.0  0.0 95.2  0.0
  6.2 13.8 80.0  0.0  0.0
  2.9 97.1  0.0  0.0  0.0
  1.0 58.7  9.0  0.0 31.2
 15.7 84.3  0.0  0.0  0.0
 18.6  3.9  0.0 77.4  0.0
 83.9 16.1  0.0  0.0  0.0
  0.0  6.3  0.0  0.0 93.7
  4.5  0.0  0.0 95.5  0.0
  0.0  4.2  6.9 88.9  0.0
  0.0 18.0 82.0  0.0  0.0
  5.0 95.0  0.0  0.0  0.0
 38.4 45.5 16.1  0.0  0.0
 58.2 41.8  0.0  0.0  0.0
  0.0  0.0  0.0 40.9 59.1
  0.0  0.0 16.2 13.0 70.8
  1.7 18.8  0.0 44.6 34.9
   .4  0.0 38.7 60.9  0.0
  0.0  2.5 43.1 42.9 11.5
  2.7 14.5 41.4 18.2 23.2
 16.0 39.1 14.4 30.5  0.0
 84.8 15.2  0.0  0.0  0.0
  0.0  7.0  0.0 93.0  0.0
  0.0  0.0  0.0 70.7 29.3
  3.2  0.0  0.0 96.8  0.0
  0.0 20.9  0.0 79.1  0.0
  0.0 63.5 36.5  0.0  0.0
 22.2 77.8  0.0  0.0  0.0
 23.8 76.2  0.0  0.0  0.0
 14.9 85.1  0.0  0.0  0.0
 55.3 44.7  0.0  0.0  0.0
 71.4 28.6  0.0  0.0  0.0
 55.8 44.2  0.0  0.0  0.0
 61.4 38.6  0.0  0.0  0.0
  0.0  0.0  0.0 37.3 62.7
  0.0  0.0  0.0 14.5 85.5
  0.0 15.8 25.3 58.9  0.0
  0.0 60.0 40.0  0.0  0.0
 23.6 76.4  0.0  0.0  0.0
 51.1 48.9  0.0  0.0  0.0
  0.0  7.4 44.3  0.0 48.2
  0.0 42.8 57.2  0.0  0.0
  0.0 42.5 57.5  0.0  0.0
  2.4 22.3 39.1 36.2  0.0
  0.0 61.3 38.7  0.0  0.0
 38.5 61.5  0.0  0.0  0.0
 75.6 24.4  0.0  0.0  0.0
```

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  9.1 91.9  0.0  0.0  0.0
 10.2 30.7 59.1  0.0  0.0
  4.0 96.0  0.0  0.0  0.0
 80.5 19.5  0.0  0.0  0.0
 30.2  0.0 69.8  0.0  0.0
 40.0 60.0  0.0  0.0  0.0
 65.8 34.2  0.0  0.0  0.0
  3.2 96.8  0.0  0.0  0.0
  3.1 96.9  0.0  0.0  0.0
  0.0 85.1 14.9  0.0  0.0
  0.0 85.3 14.7  0.0  0.0
  2.5 97.5  0.0  0.0  0.0
  4.4 81.6 14.0  0.0  0.0
  0.0  0.0 25.4  0.0 74.6
  2.4 27.3 70.2  0.0  0.0
  5.9 42.4 51.7  0.0  0.0
 88.8 11.2  0.0  0.0  0.0
 79.8 20.2  0.0  0.0  0.0
 59.6 40.4  0.0  0.0  0.0
 35.6 64.4  0.0  0.0  0.0
 78.1 21.9  0.0  0.0  0.0
 15.4  0.0 84.6  0.0  0.0
 43.9 56.1  0.0  0.0  0.0
 46.4 53.6  0.0  0.0  0.0
 13.2 86.8  0.0  0.0  0.0
 24.7 75.3  0.0  0.0  0.0
 13.3 86.7  0.0  0.0  0.0
  7.7 92.3  0.0  0.0  0.0
 49.2 50.8  0.0  0.0  0.0
  0.0 83.7 16.3  0.0  0.0
  1.5 34.3 64.2  0.0  0.0
  6.1 93.9  0.0  0.0  0.0
 26.2 73.8  0.0  0.0  0.0
  0.0 40.9 41.5 17.6  0.0
  3.2 31.4 65.4  0.0  0.0
 15.8 84.2  0.0  0.0  0.0
 15.7 84.3  0.0  0.0  0.0
 13.0 87.0  0.0  0.0  0.0
  0.0 64.1 35.9  0.0  0.0
  2.5 27.1 70.4  0.0  0.0
 11.2 88.8  0.0  0.0  0.0
  6.6  0.0 38.3 55.1  0.0
 40.1  0.0  0.0 59.9  0.0
 16.7 83.3  0.0  0.0  0.0
 29.4 70.6  0.0  0.0  0.0
 14.5 85.5  0.0  0.0  0.0
  0.0 38.8 61.2  0.0  0.0
 16.2 83.8  0.0  0.0  0.0
 28.6 38.5 33.0  0.0  0.0
  0.0  0.0 25.0 75.0  0.0
  0.0  9.1  0.0 90.9  0.0
 23.7 76.3  0.0  0.0  0.0
 23.4 76.6  0.0  0.0  0.0
 10.4 89.6  0.0  0.0  0.0
 33.3 66.7  0.0  0.0  0.0
  0.0  0.0 87.5 12.5  0.0
  2.2 13.5 50.9 33.3  0.0
  1.8 60.8 25.5 11.9  0.0
  4.0 75.1  7.0 13.9  0.0
```

```
   0.0  6.6  0.0  0.0 93.4
   0.0  0.0 17.1  0.0 82.9
   0.0 18.5  0.0 81.5  0.0
  29.2 56.5 14.4  0.0  0.0
  44.3 55.7  0.0  0.0  0.0
  40.0 60.0  0.0  0.0  0.0
   1.0 99.0  0.0  0.0  0.0
   9.6 59.1 31.3  0.0  0.0
   0.0 25.1  0.0 74.9  0.0
   0.0 16.4 83.6  0.0  0.0
   5.8 22.6 71.6  0.0  0.0
  25.2 74.8  0.0  0.0  0.0
  15.3 84.7  0.0  0.0  0.0
  39.6 60.4  0.0  0.0  0.0
  25.8 38.6 15.6 20.0  0.0

DEPARTMENT NAMES

         ANTHROPOLOGY
          ASTRONOMY
            BOTANY
          CHEMISTRY
      EAST ASIAN STUDIES
           FINE ART
          GEOGRAPHY
           GEOLOGY
           HISTORY
       ISLAMIC STUDIES
 ITALIAN/HISPANIC STUDIES
         MATHEMATICS
          PHILOSOPHY
           PHYSICS
 POLITICAL SCI/ECONOMICS
          PSYCHOLOGY
       SLAVIC STUDIES
          SOCIOLOGY
           ZOOLOGY
 CLASSICS - UNIV. COLLEGE
 ENGLISH - UNIV. COLLEGE
  ETHICS - UNIV. COLLEGE
  FRENCH - UNIV. COLLEGE
  GERMAN - UNIV. COLLEGE
 NEAR EASTERN STUDIES- UC
   CHEMICAL ENGINEERING
    CIVIL ENGINEERING
  ELECTRICAL ENGINEERING
  INDUSTRIAL ENGINEERING
  MECHANICAL ENGINEERING
 METALLURGY/MATERIALS SCI
     AEROSPACE STUDIES
  SCHOOL OF ARCHITECTURE
     SCHOOL OF BUSINESS
 INSTITUTE OF CHILD STUDY
 INST OF COMPUTER SCIENCE
   FACULTY OF DENTISTRY
      DENTAL HYGIENE
 FACULTY OF FOOD SCIENCES
   FACULTY OF FORESTRY
      FACULTY OF LAW
 SCHOOL OF LIBRARY SCI.
    FACULTY OF MUSIC
   SCHOOL OF NURSING
  FACULTY OF PHARMACY
PHYSICAL AND HEALTH EDUC
 SCHOOL OF SOCIAL WORK

DEPARTMENTAL ROOM UTILIZATION

 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0
 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0
 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0 60.0

DEPARTMENTAL TEACHING WEEK LENGTH(HOURS)

 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0
 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0
 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0 35.0

DEPARTMENTAL PERCENTAGE OF SMALL CLASSES TAUGHT IN PROFESSORS, OFFICES

 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0
 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0
 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0 20.0

DEPARTMENTAL ROOM ASSIGNMENT PARAMETER

  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0

DEPARTMENTAL LIST OF BUILDING PRIORITIES

  33  72  32  73 ZERO
  78A 73  36  33 ZERO
  11  25   7  83AZERO
  73  33  32   8 ZERO
  33  72  32  73 ZERO
  33  32  72  73 ZERO
  33  32  72  73 ZERO
   7   8  20  83AZERO
  33  72  32  73 ZERO
  33  72  32  73 ZERO
  77  72  33  32 ZERO
  33  72  32  73 ZERO
  67  28  79  78AZERO
  78A 73  36  33 ZERO
  33  32  72  73 ZERO
  33  72  32  73 ZERO
  33  72  73  32 ZERO
  61A 78A 73  36 ZERO
  72  33  32   1 ZERO
   1  33  72  73 ZERO
   1  33  72  73 ZERO
   1  33  72  73 ZERO
   1  33  72  73 ZERO
   1  33  72  73 ZERO
   1  33  72  73 ZERO
   8   7  70   9 ZERO
```

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    70    9    8   27 ZERO
    70    9    8   27 ZERO
    20    7    9   70 ZERO
    20    7    9   70 ZERO
     8    7   20   83AZERO
    70    9   27    8 ZERO
    28    8   78A  79 ZERO
    38   33   72    1 ZERO
    53   33    1   32 ZERO
    78A   9   70   36 ZERO
    65   83A   7   25 ZERO
    65   83A   7   25 ZERO
    15   51   17   40 ZERO
    27   70   36    9 ZERO
    40   51    1   17 ZERO
    83A  83B   7    8 ZERO
    51  100   17   40 ZERO
    36   78A  73   79 ZERO
    79   78A  36   28 ZERO
     2    1   33   72 ZERO
   100   51   17    1 ZERO

   DEPARTMENTAL AVERAGE INTERVAL SECTION SIZE

      7.6 31.8 74.3130.9193.0
      4.9 36.0 67.3140.0250.0
      7.2 33.6 81.6135.0250.0
     10.6 35.6 81.6131.2250.0
      3.5 43.0 80.0140.0250.0
      9.4 42.7 75.7101.0250.0
     10.9 32.0 75.6154.0194.0
      8.4 28.2 95.0152.0250.0
      9.3 23.0 79.0154.4283.8
      2.2 40.0 80.0140.0250.0
     10.9 29.5 63.8140.0250.0
      7.0 37.4 74.8139.0213.0
      8.2 44.6 82.3136.0214.0
      6.3 38.2 76.2136.0231.0
      8.3 38.6 76.6121.0212.4
      8.1 39.1 71.0144.0217.0
      8.0 26.0 80.0140.0250.0
      9.2 33.4 68.5144.4255.4
     10.8 38.2 80.6100.0185.0
     10.0 40.0 80.0140.0250.0
     10.0 40.0 80.0140.0250.0
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  10.0 40.0 80.0140.0250.0

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   UNIVERSITY COLLEGE
APPLIED SCIENCE AND ENG.

NUMBER OF DEPARTMENTS IN A PARTICULAR FACULTY

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